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COMPILATION OF DATA ON CREW EMERGENCY ESCAPE SYSTEMS

John O. Bull

Edward L. Serocki

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THE BOEING COMPANY, RENTON, WASHINGTON. P.O. BOX 707,

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AIR FORCE FLIGHT DYNAMICS LABORATORY
RESEARCH AND TECHNOLOGY DIVISION
AIR FORCE SYSTEMS COMMAND
WRIGHT PATTERSON AIR FORCE BASE, OHIO

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FOREWORD

The research covered in this report was performed by The Boeing Company, Renton, Washington, for the Air Force Flight Dynamics Laboratory, Research and Technology Division, Air Force Systems Command, Wright-Patterson Air Force Base, under AF Contract No. AF 33(615)-2378, project No. 1362, Task No. 136203. The Air Force program monitor was Mr. Marvin C. Whitney, office symbol FDFR, Recovery and Crew Station Branch. The research was conducted from February 1965 to August 1966.

This research is part of an effort to determine the crew escape design requirements for VTOL and low-altitude dash vehicles; investigate various crew escape concepts such as ejection seats, encapsulated seats, nose and pod-type escape capsules; study the associated escape problems such as stability, critical timing, automatic initiation, high dynamic forces, high performance escape rockets, etc; and determine the theoretical feasibility of the techniques and concepts that will meet the vehicle requirements.

This report covers a part of the investigation which consisted of acquiring and compiling available data for existing and advanced escape systems and subsystems. All work toward this effort by The Boeing Company Airplane Division Product Development Technology Section was coordinated by John O. Bull, escape systems research engineer. Acknowledgement is made by the authors to Mr. Larry J. Nolan, Mr. Jakob Schor, and Mr. Charles W. Bird of Boeing for their aid in preparing the information required for this report. Acknowledgement is also made of the assistance provided by the following facilities who contributed information and data necessary for the accomplishment of Phase II: Aero-Space Crew Equipment Laboratory, Philadelphia, Pa.; Bendix Radio Division, Baltimore, Maryland; Bureau of Naval Weapons, Washington, D.C.; David Clark Co., Inc., Worcester, Mass.; Douglas Aircraft Co., Inc. Long Beach, Calif.; E. I. du Pont de Nemours and Co., Wilmington, Del.; Air Force Flight Dynamics Lab., Research and Technology Div. AFSC, WPAFB, Ohio; Frankford Arsenal, Philadelphia, Pa.; General Dynamics Corp., Convair Div., San Diego, Calif., and Ft. Worth Div., Ft. Worth, Texas; B. F. Goodrich Aerospace and Defense Products Div., Akron, Ohio; Goodyear Aerospace Corp., Akron, Ohio; Lockheed California Co., Burbank, Calif.; LTV, Aeronautics Div., Dallas, Texas; Martin-Baker Aircraft Co., Ltd., Denham, Uxbridge, Middlesex, England; McDonnell Aircraft Corp., St. Louis, Missouri; Thiokol Chemical Corporation, Elkton, Maryland; North American Aviation, Inc., Columbus Div., Columbus, Ohio; North American Aviation, Inc., Los Angeles Div., Los Angeles, Calif.; Pacific Scientific Co., Los Angeles, Calif.; Rocket Power, Inc., Mesa, Ariz.; Stanley Aviation Corp., Denver, Colo.; Stencel Aero Engineering Corp., Asheville, N. C.; Talley Industries, Mesa, Ariz.; U. S. Army Transportation Research Command, Ft. Eustis, Va.; U. S. Naval Weapons Laboratory, Dahlgren, Va.; Walter Kidde Ltd., Northolt, Middlesex, England; and Weber Aircraft Corp., Burbank, Calif.

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The manuscript was released by the authors in August 1966 for publication as a technical report.

Publication of this report does not constitute Air Force approval of the report's findings or conclusions. It is published only for the exchange and stimulation of ideas.

SOLOMON R. METRES, Acting Chief
Recovery and Crew Station Branch
Vehicle Equipment Division
AF Flight Dynamics Laboratory

ABSTRACT

A comprehensive group of appropriate open ejection seats, encapsulated ejection seats, cockpit pod capsules, separable nose capsules, and subsystems are described. The descriptions provide information on items such as initiation, crew positioning and restraint, emergency pressurization and oxygen, seat-man separation, capsule separation, rocket motors, rocket catapults, stabilization, deceleration, recovery parachute, landing impact attenuation, flotation, location aids, and survival equipment or provisions. Information is also provided on escape system performance, tests, accelerations experienced, stability characteristics, trajectories, escape time sequence, envelope dimensions, weights, production or development status, and projected system improvements.

TABLE OF CONTENTS

TABLE OF CONTENTS (Cont)

h

ILLUSTRATIONS

ILLUSTRATIONS (Cont)

ILLUSTRATIONS (Cont)

ILLUSTRATIONS (Cont)

ILLUSTRATIONS (Cont)

ILLUSTRATIONS (Cont)

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TABLES

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SECTION I

INTRODUCTION

The objectives of this study are to define crew escape requirements for VTOL and supersonic low-altitude dash vehicles, gather data on current and projected escape systems and subsystems, evaluate the various escape concepts, and provide trade data and design criteria that will be useful in the selection, design and evaluation of escape systems for future advanced aircraft.

The results of the study are presented in two separate reports. This report covers that portion involving the compilation of data on crew emergency escape systems, and presents descriptions of current and projected escape systems, subsystems, and components.

SECTION II

ESCAPE SYSTEMS AND SUBSYSTEMS INVESTIGATION

This investigation consisted of acquiring and compiling data to describe appropriate open ejection seats, encapsulated ejection seats, cockpit pod capsules, separable nose capsules, miscellaneous escape devices, and subsystems. A general description of each escape system concept and subsystem is included in this report. The descriptions include technical data, graphs, drawings, photographs, and other information necessary to describe each system.

1. OPEN EJECTION SEATS

a. CONVAIR "B" SEAT

The Convair "B" seat is a rocket-powered, open-type, upward ejection seat. It was designed in 1957 to include recommendations of the joint USAF/Industry Crew Escape System Committee. The seat was subsequently installed in the supersonic F-106A and B airplanes to conform to the original requirement for escape capability within the airplane mission profile. Being the first USAF ejection seat designed specifically for supersonic escape, particular emphasis was placed on high-speed fin-tip clearance, windblast protection, packaging of the seat occupant and retention of equipment, seat stabilization, and safe deceleration rates. Low-level ejection was also an important, but secondary aspect of the design. In 1965, the results of an Air Force review of high-speed and low-speed ejection statistics indicated a need to favor low-speed escape capability, so the Convair "B" seat was replaced in the F-106 with a Weber modified subsonic upward ejection seat having zero-speed, zero-altitude capability. The change provided improved reliability and low-speed, low-altitude escape capability.

Figure 1 shows the general arrangement of the "B" seat, and Fig. 2 shows the installation space requirements. Figure 3 is a general schematic of the system.

The ejectable seat consists of a D-ring ejection handle; integrated harness; combination shoulder strap inertia and power take-up reel; upward rotating foot pans, seat pan, and leg guards; gas-operated reels for foot cable retraction; two gas-operated telescoping booms for stabilization; drag chute ejector with aneroid feature; drag and personnel recovery parachutes; chaff dispenser; oxygen bottle; two survival kits; and emergency harness release handle. The ejectable seat is attached to the nonejectable structure by four breakaway bolts. The nonejectable hardware consists of a vertical adjustment seat electrical actuator; guide rails; gas-operated, hydraulically-damped seat vertical thruster; two gas-operated, hydraulically-damped seat rotational thrusters; and an electrical circuit incorporating an airspeed switch.

Figure 4 shows the major phases of the ejection sequence. Ejection is initiated by pulling the D-ring. This jettisons the canopy, trips the automatic flight control system disconnect switch, retracts and locks the shoulder harness, retracts the seat occupant's feet, and raises the foot pans, seat pan, and leg guards. Feet retraction and canopy jettison safety locks release,

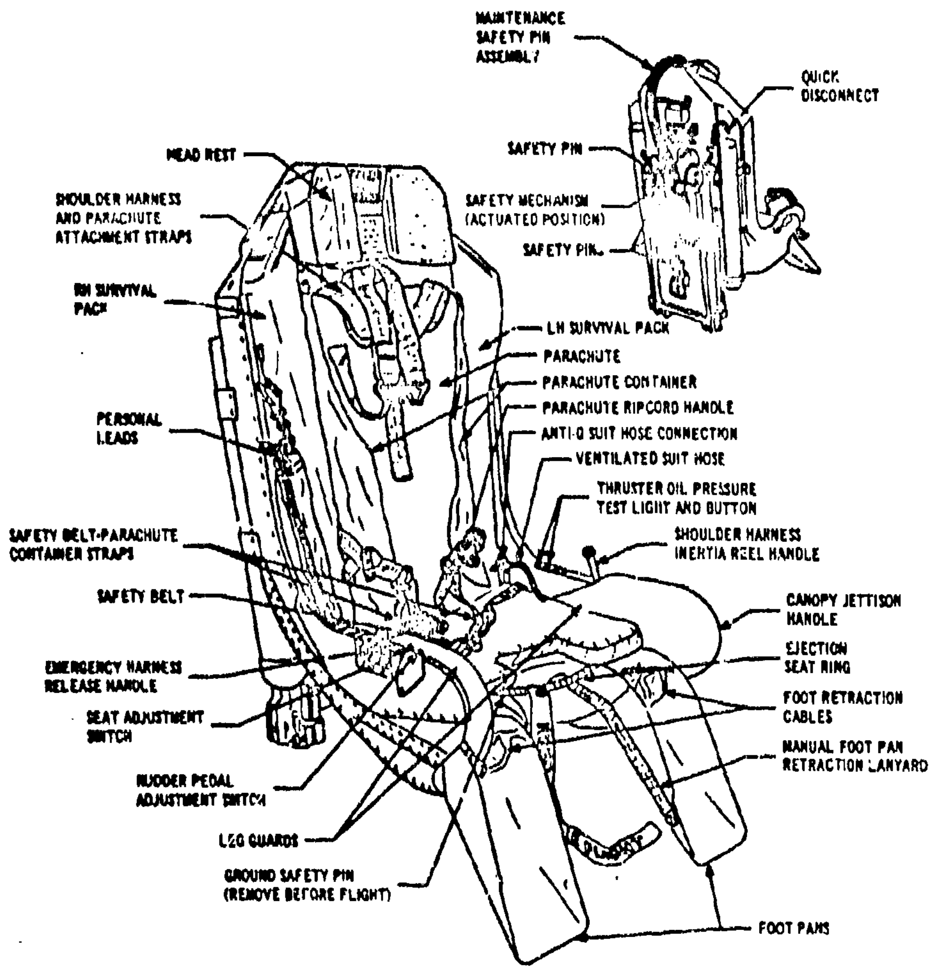


Figure 1. Convair "B" Seat – General Arrangement

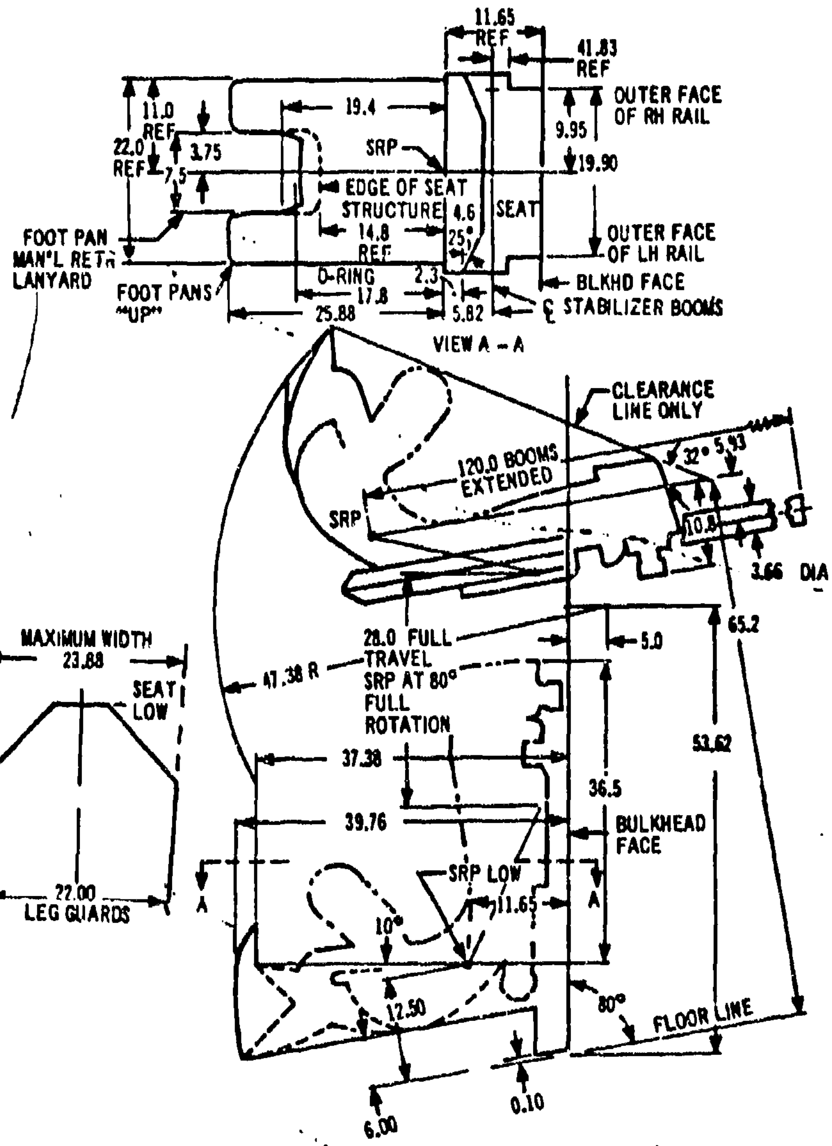
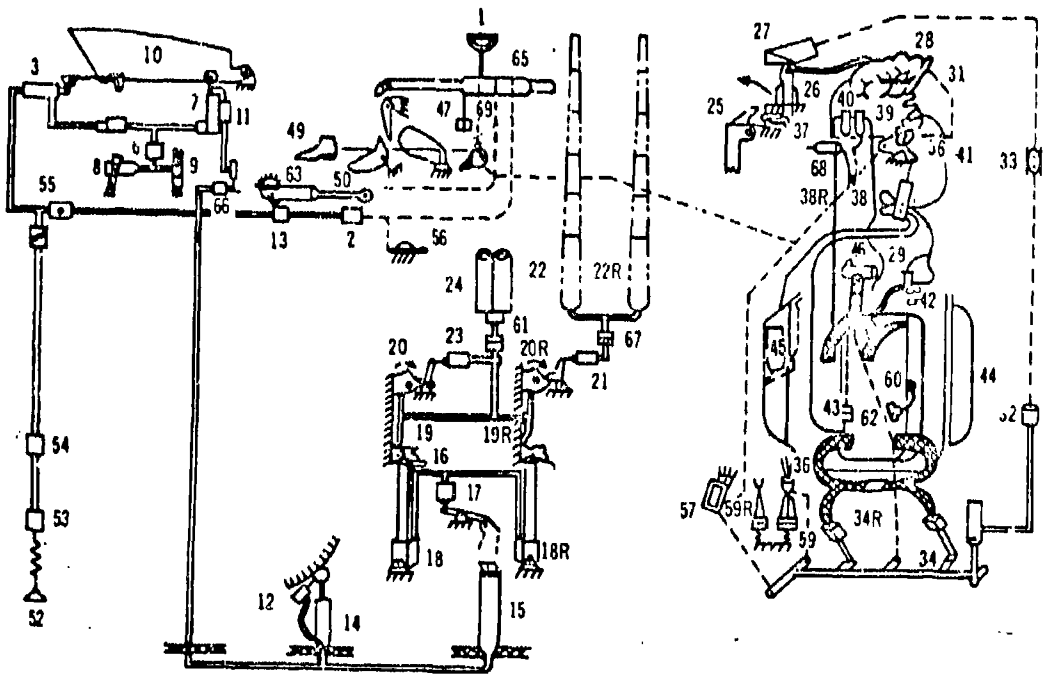


Figure 2. Convair "B" Seat Space Envelope

1. EJECTION CONTROL (D RING)
2. MECHANICALLY FIRED INITIATOR
3. LATCH THRUSTER
4. CANOPY LATCHES
5. GAS – FIRED INITIATOR
6. GAS – FIRED INITIATOR
7. CANOPY REMOVER
8. WIRE CUTTER
9. HOSE DISCONNECT
10. CANOPY
11. MECHANICALLY FIRED INITIATOR
12. GAS-ACTUATED EXACTOR
13. HOSE DISCONNECT
14. SEAT ADJUSTMENT ACTUATOR
15. VERTICAL SEAT THRUSTER
16. ANTIROTATION LOCKS
17. MECHANICALLY FIRED INITIATOR
18. ROTATIONAL THRUSTER
19. BREAKAWAY BOLTS (LOWER)
20. BREAKAWAY BOLTS (UPPER)
21. MECHANICALLY FIRED INITIATOR
22. STABILIZING BOOMS
23. MECHANICALLY FIRED INITIATOR
24. SEAT ROCKET MOTOR
25. ARMING CAM
26. DRAG CHUTE EJECTOR (DROGUE GUN)
27. HEADREST LID
28. DRAG PARACHUTE
29. LANYARD CUTTER (0.8 SEC DELAY)
30. HEADREST LATCH
31. HEADREST
32. MECHANICALLY FIRED INITIATOR
33. CABLE DISCONNECT
34. LAP-BELT DISCONNECT
35. SHOULDER STRAP DISCONNECT
36. PERSONAL LEADS DISCONNECT (SEAT-TO-MAN)
37. DROGUE GUN TRIGGER MECHANISM
38. HESITATION RISERS
39. RISER CUTTER (1.5 SEC DELAY)
40. RISER CUTTER (1.5 SEC DELAY)
41. DEPLOYMENT LINE
42. PERSONNEL PARACHUTE
43. SURVIVAL PACK LANYARD
44. SURVIVAL PACKS
45. LIFE RAFT
46. INERTIA REEL
47. AFCS DISCONNECT SWITCH
48. FOOT AND SEAT PAN ACTUATOR
49. OCCUPANT'S FEET
50. FOOT PANS
51. SEAT PAN AND LEG GUARDS
52. EXTERNAL CANOPY JETTISON CONTROL HANDLE
53. MECHANICALLY FIRED INITIATOR
54. GAS-FIRED INITIATOR

A



ππππ INDICATES SEAT OR LAUNCHING MECHANISM

xxxx INDICATES AIRPLANE STRUCTURE

55. CHECK VALVE
56. ALTERNATIVE CANOPY JETTISON CONTROL HANDLE
57. ALTERNATIVE DISCONNECT CONTROL
58. ALTERNATIVE LANYARD CUTTER
59. PERSONAL LEADS DISCONNECT (AIRCRAFT-TO-SEAT)
60. RIPCORD HANDLE
61. BALLISTIC HOSE DISCONNECT (AUTOMATIC)
62. MANUAL KIT DISCONNECT
63. VERTICAL THRUSTER TRIGGERING TORQUE TUBE MECHANISM
64. EJECTION MECHANISM SAFETY LOCKS
65. EJECTION CONTROL SPOOL
66. INITIATOR-EXACTOR COMBINATION
67. BALLISTIC HOSE DISCONNECT (AUTOMATIC)
68. ANTIHESITATION CUTTER
69. ANTIHESITATION CUTTER SWITCH

Figure 3. General Schematic of Convair Supersonic Aircraft Escape System

B

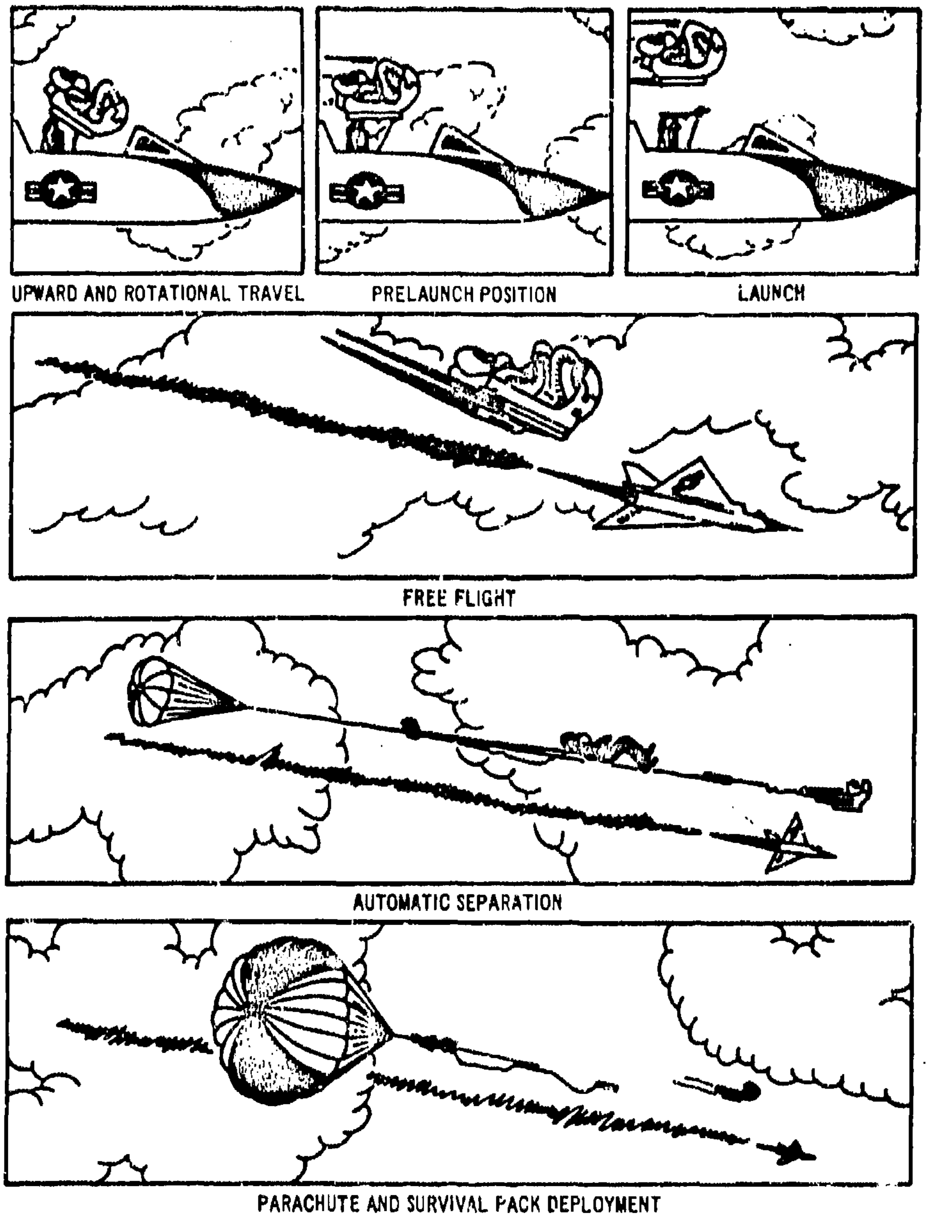


Figure 4. Convair "B" Seat Ejection Sequence

allowing further pull on the D-ring. Further pull on the D-ring disconnects the seat actuator and fires the seat vertical thruster, thus moving the seat up the rails. At the beginning of vertical thruster stroke, the hose disconnect and personal-leads-disconnect is separated, and at the end of vertical thruster stroke the two rotational thrusters are fired, causing the seat to assume a horizontal position on top of the airplane. During rotation to the horizontal launch position, the gas-operated stabilization booms are extended, the four breakaway attachment bolts are fired, and the rocket is ignited, propelling the seat away from the airplane. (On F-106B airplanes the forward and rear seats are interconnected in such a manner that the rear seat is always ejected first.)

Separation of the seat from the airplane arms the aneroid controlled drag parachute ejector, which fires a 2-second time delay initiator if ejection is initiated below 15,000 feet. If ejection is above 15,000 feet, firing of the 2-second delay initiator is prevented until the seat has descended to 15,000 feet. At the end of the 2-second delay a slug is fired from the ejector, causing headrest lid removal, deployment of the drag parachute, and firing of the initiator to release the seat occupant's harness (except feet cables).

At speeds exceeding 280 KIAS, drag parachute pull separates the headrest from the seat, which triggers the 1.5-second delay riser cutters. Continued drag parachute pull extracts the seat occupant with personnel parachute from the seat by the hesitation risers. As the occupant is pulled from the seat his feet become separated from the feet retention cables, and the man decelerates until the 1.5-second delay riser cutters sever the hesitation risers. Drag parachute force then pulls the main personnel chute from its pack, which fires an 0.8-second delayed-action line cutter to separate the drag parachute and headrest from the main parachute. The main parachute then fills and the crewmember descends to earth.

At airspeeds of 280 KIAS or less, an airspeed switch closes and, when the D-ring is pulled, the antihesitation cutter in the headrest cuts the hesitation riser. This causes the drag chute to immediately deploy the main parachute at low airspeeds, eliminating the 1.5-second delay that occrs at airspeeds above 280 KIAS. The remainder of the ejection sequence is the same as described for high-speed ejection.

The performance envelope of the Convair "B" seat is shown in Fig. 5 and has been demonstrated by at least 15 sled tests and 11 flight tests. During sled tests utilizing dummies of 5 to 95 percentiles, satisfactory dummy recoveries were accomplished from 154 KEAS to 755 KEAS, as shown in Fig. 6. At low speeds the relationship between rocket thrust line and ejected mass center of gravity significantly affects trajectory height, as evidenced by a 173 KEAS, 95 percentile dummy trajectory peak of 91 feet, compared with a 168 KEAS, 5 percentile dummy trajectory peak of 215 feet. Accelerations imposed on the dummy during a 755 KEAS sled test are shown in Fig. 7.

Flight tests were conducted at altitudes of 10,000 to 50,000 feet and at airspeeds of 176 to 733 KIAS. One flight test was conducted by ejecting a human subject at 22,580 feet and 337 KIAS (Mach 0.77). Also, an 84,150 foot altitude drop test using a dummy was accomplished to study free-fall characteristics.

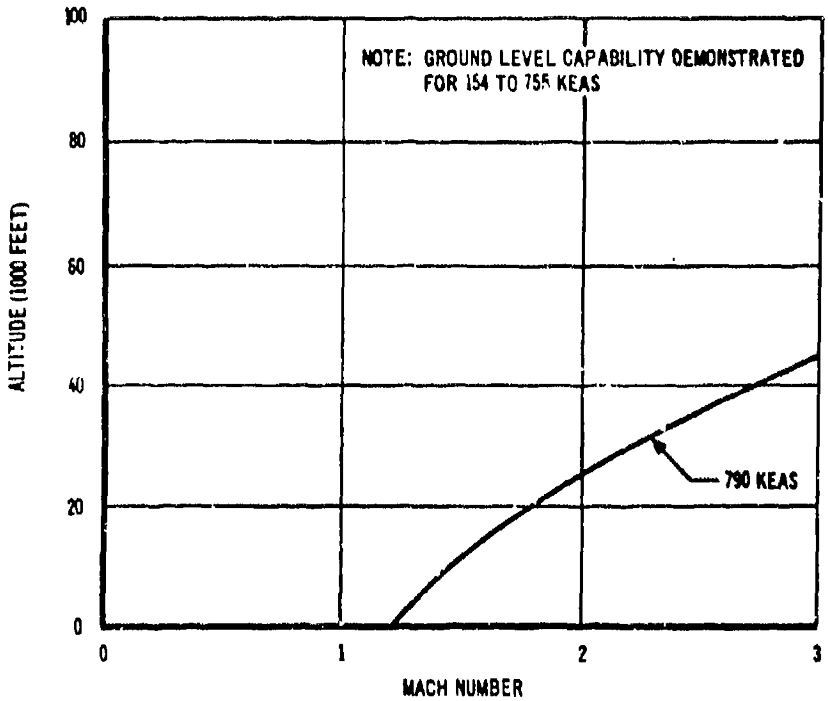


Figure 5. Convair "B" Seat Performance Envelope

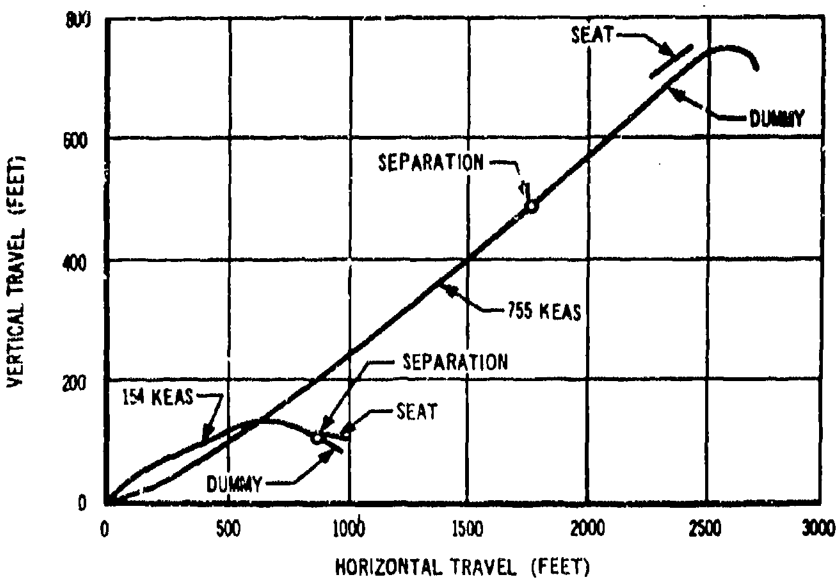


Figure 6. Convair "B" Seat Trajectories – 154 and 755 KEAS Sled Tests

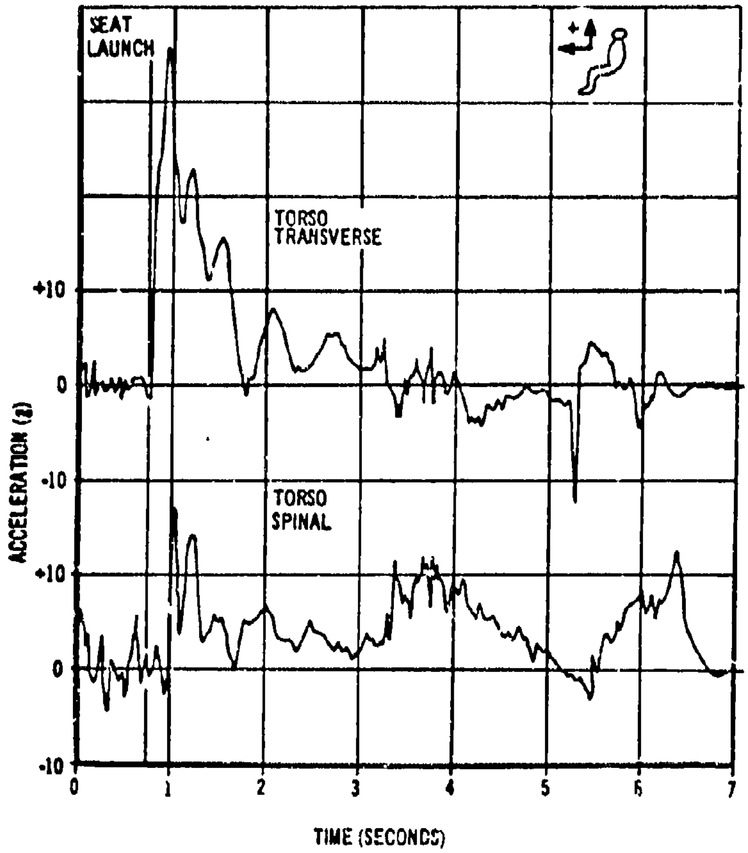


Figure 7. Convair "B" Seat Dummy Torso Acceleration – 755 KEAS Sled Test

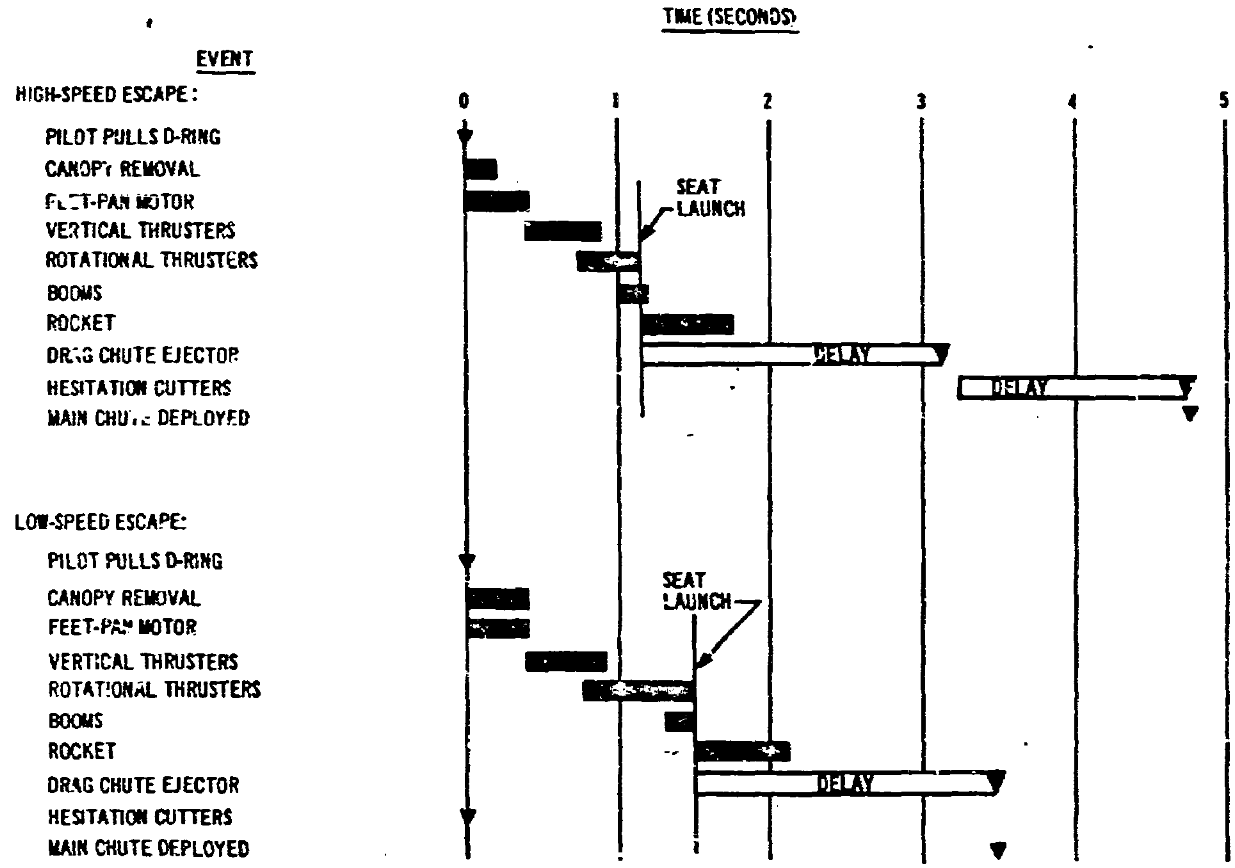


Figure 8. - Convair "B" Seat Event Time Values

From these tests typical escape event time values are shown in Fig. 8. In addition, all components have been environmentally tested per MIL-E-5272; each cartridge item has been fired more than 100 times at temperatures from -65°F to 200°F; and numerous subsystem tests have been accomplished on the oxygen system, parachute system, inertia reel, seat actuator, ballistic items, and basic seat.

The Convair "B" seat rocket, stabilizing booms, vertical thruster, rotational thruster, foot pan actuator, and breakaway bolts are discussed in Section II.6 of this report.

Table I gives the seat weight breakdown.

Table I. Convair "B" Seat Weight Breakdown

Item	Weight (Pounds)
Seat	128.0
Seat adjustment actuator	4.5
Foot and seat pan actuator	15.8
Oxygen system	11.4
Parachute system	37.2
Survival pack assembly	37.4
Breakaway bolts (4)	5.2
Carriage	39.9
Rocket	31.5
Initiators	3.2
Vertical thruster	17.7
Rotational thruster (2)	13.6
Booms (2)	33.1
Rails	36.3
Triggering mechanism	2.4
Total (Less Man and Personal Equipment)	417.2

NOTE: Ejectable weight of seat and 95 percentile man equipped with flight coveralls, HGU-2/P helmet, high-top shoes, and integrated harness is 515 pounds.

b. DOUGLAS ESCAPAC IC SEAT

The Douglas Escapac IC is a modified version of the Navy qualified Escapac I rocket-catapult ejection seat which is installed in the A4 (A4D) Skyhawk. Modification consisted of replacing the RAPEC I with a higher impulse rocket-catapult (RPI 2174-16) and adding a zero delay parachute lanyard to increase escape capability. The higher energy rocket-catapult provides added trajectory height and the zero delay lanyard assures early deployment of the parachute to provide the zero-zero capability. Due to the minor nature of these modifications, the high-speed performance of the seat is not affected significantly, and its service-proven reliability is maintained. Therefore, the system, as modified, will provide safe escape for a crewman when ejection is initiated at ground level, at any altitude, and at speeds from zero to 600 knots.

The Escapac IC ejection seat system is installed in the Ling-Temco-Vought XC-142 and A-7A, Canadair CL-84 V/STOL, Douglas TA-4F, Lockheed XV-4A, North American OV-10A, and General Dynamics Charger airplanes. A photograph of the seat is shown in Fig. 9, and the overall installation dimensions are shown in Fig. 10.

Operation of either the face curtain or the seat D-ring ejection control initiates a sequence to achieve automatic recovery of the pilot. The system is also operable manually as shown by the ejection sequence schematic in Fig. 11. After initiation, the canopy is jettisoned and the rocket catapult fires ejecting the seat. Due to the canopy interlock mechanism, the canopy must be jettisoned automatically, or manually, prior to catapult firing. As the seat is propelled up the guide rails, the parachute 2.0-second delay cartridge is actuated by a lanyard, the 1.0-second delay harness release actuator is armed by a striker plate, and the emergency oxygen is turned on.

After the 1.0-second delay, the harness release actuator separates the pilot's harness at three points, releases both ejection controls from the seat, and opens the nitrogen bottle to inflate the seat-man separation bladders. One bladder is located under the seat pan assembly, and the other behind the parachute kit. As the bladders inflate, the seat is forcefully separated from the pilot. After one additional second and when below 10,000 feet, the NB-9 (28-foot flat circular canopy) parachute is deployed. If the parachute 2.0-second delay cartridge was not actuated as the seat ejected, it is actuated as the pilot separates from the seat. This increases the parachute pack opening time delay from 2.0 to 3.0 seconds. At high altitudes an aneroid contained in the parachute actuator will delay opening until a pre-set altitude is reached. A pararaft kit, with supplies, is provided for survival at sea or on land until the pilot is rescued. Several Escapac IC configurations utilize a rigid seat survival kit (RSSK-8).

An outstanding subsystem used in the Escapac IC system is the DART Stabilization system described as follows:

- Trajectory and seat rotational control are achieved by incorporation of the directional automatic realignment of trajectory (DART) stabilization system. If CG/thrust alignment induces rotation of the ejected mass, automatic correction is supplied by DART to limit the system rotation at rocket burnout to a preprogrammed value.

Table II is the ejection seat weight breakdown.

A series of five tests was conducted on the Douglas Escapac IC ejection seat to demonstrate the system for the zero-speed, zero-altitude condition. These tests were conducted by the Douglas Aircraft Company, Aircraft Division, using the Long Beach Municipal Airport as the test site. In all tests, successful recovery of the dummy was achieved, demonstrating that the performance of the Escapac 1 seat could be extended to include the zero-zero condition.

Typical test trajectories and event-time sequence are shown in Figs. 12 and 13 for the 5th and 95th percentile crewman. The zero delay parachute lanyard was not used in Tests 1 through 3 and, although full parachute inflation was

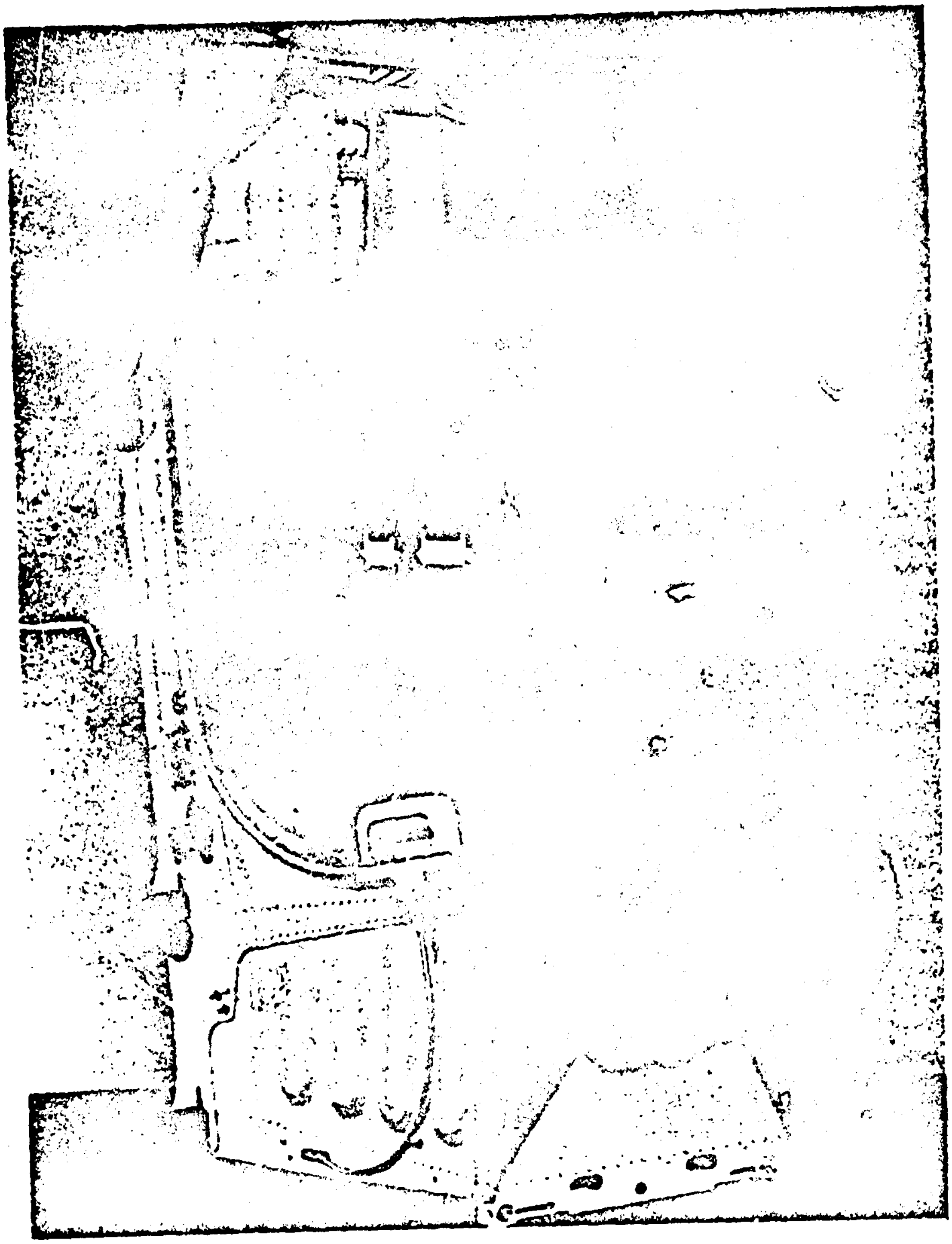


Figure 9. Douglas Escapac IC Seat

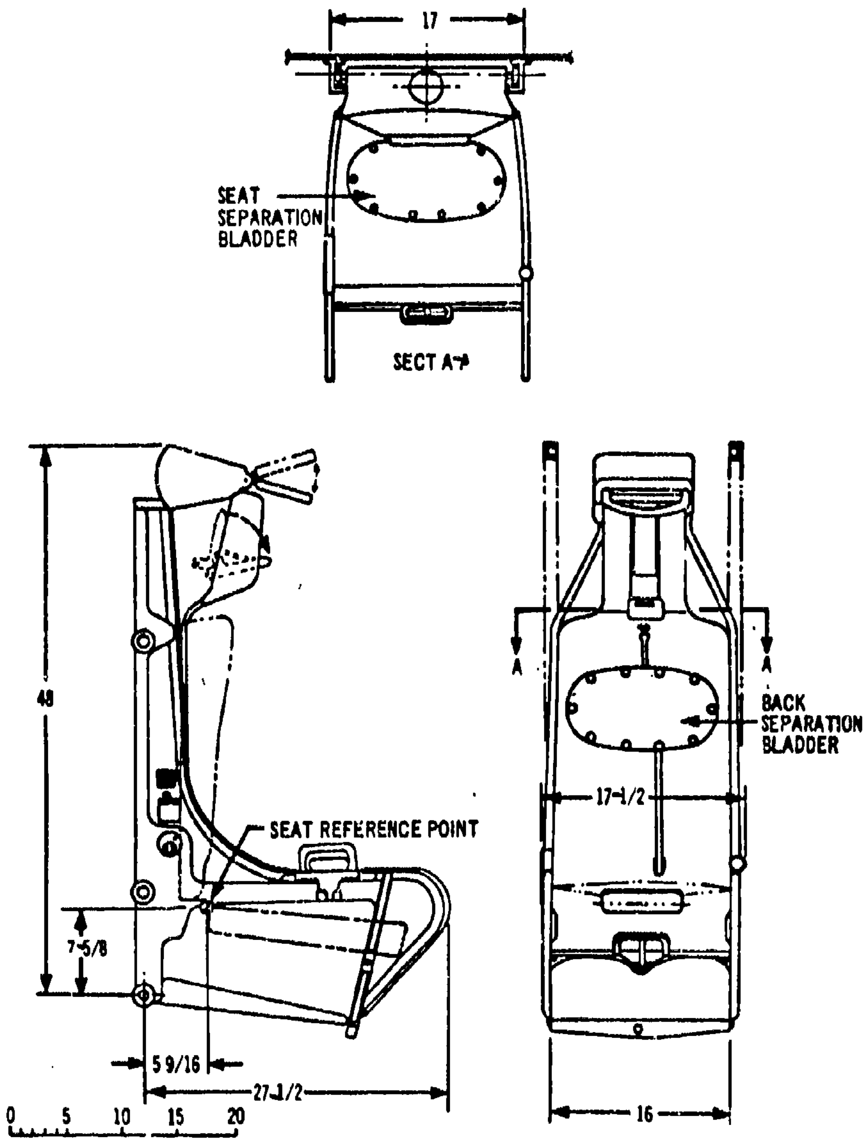


Figure 10. Douglas Escapac IC Seat – General Arrangement

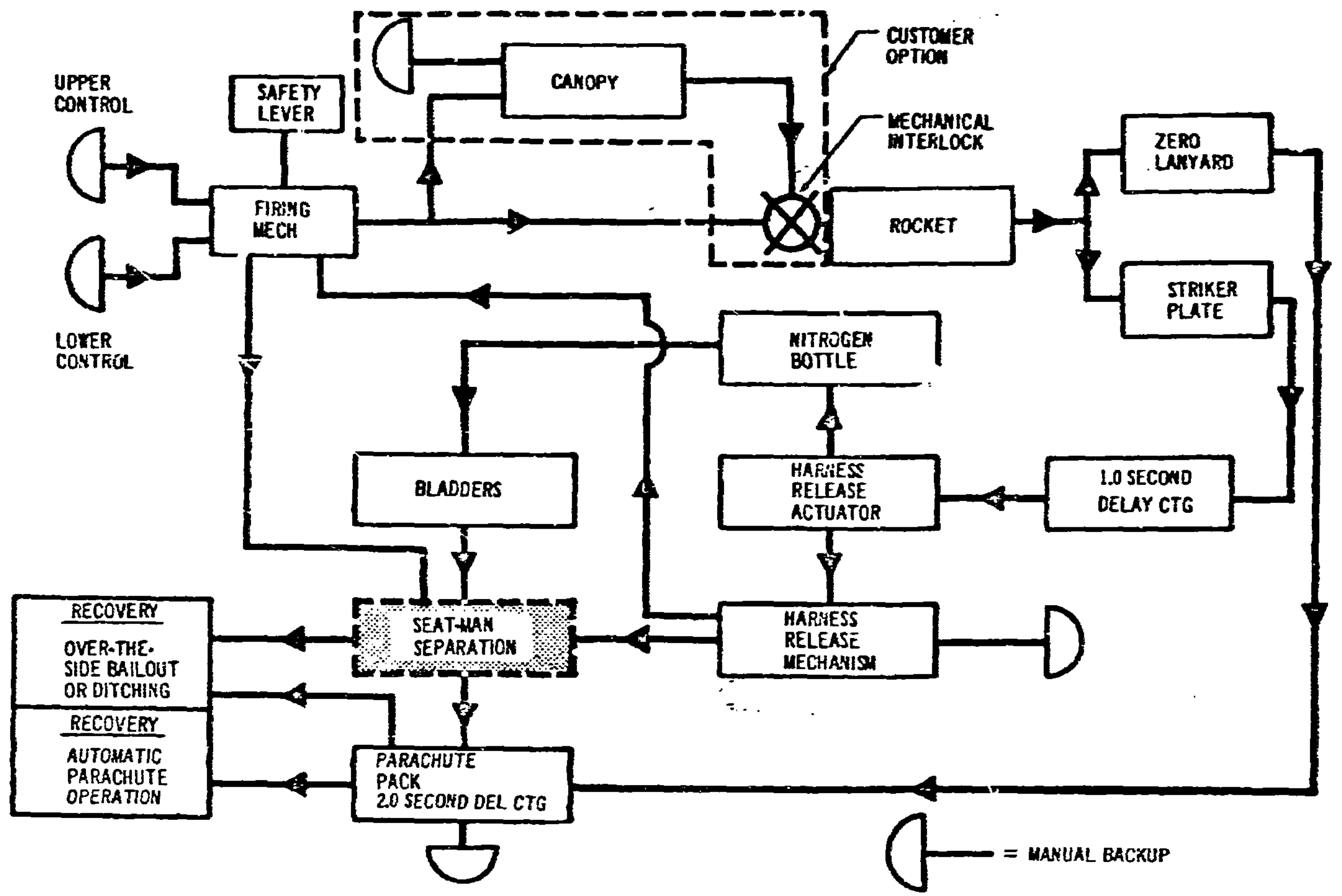


Figure 11. Douglas Escapac IC Seat – Schematic Diagram

Table II. Douglas Escapac IC Seat Weight Breakdown

	Weight (Lb) Installed	Weight (Lb) Ejectable
Basic seat structure	50.75	50.75
Rocket launch tube	6.00	---
Rocket motor and grain	21.50	21.50
Parachute assembly	25.00	25.00
Seat pan assembly	8.00	8.00
*PK-2 pararaft kit	25.00	25.00
Seat adjustment actuator	4.50	---
Guide rails	8.70	---
Total Weight	*149.45	*130.25

*With RSSK-8 add 6 lb. to total weight.

delayed, dummy recovery was accomplished at a comfortably safe height as shown in Fig. 13 (Test 2). Recovery of the dummy in Tests 1 and 3 was complete at 50 and 74 feet above the ground, respectively. Temporary entanglement of the parachute and dummy delayed full inflation. The entanglement was believed partially induced by seat/dummy pitching gyrations due to excessive CG/thrust eccentricity and partially by the low air velocity at time of deployment.

Accelerations and rates of onset were measured in three mutually perpendicular planes in the dummy's chest during Tests 4 and 5. The accelerations and rates of onset were lower than the equivalent readings in the Escapac I tests that were subsequently proven to be tolerable in operational use. It was conluded, therefore, that ejection acceleration loads imposed on the Escapac IC seat occupant were well below the human tolerance limits.

c. DOUGLAS ESCAPAC II SEAT

The Escapac II system was developed by Douglas as the basic version of the next generation of the Escapac system. The major differences between Escapac II and the Escapac IC system are the ballistically deployed parachute system, stabilization drogue parachute, backrest assembly, ballistic takeup inertia reel, a lower impulse rocket catapult, and a gyro-controlled stabilization system. A high degree of commonality with existing fleet equipment is maintained, thereby assuring high performance, reliability, comfort, and low development and maintenance cost. The system was designed to provide safe escape from ground level up, at speeds from zero knots through Mach 1.

Initiation of the system is accomplished by operation of either the face curtain or the seat D-ring. After initiation, a completely automatic sequence jettisons the canopy, actuates the ballistic inertia reel, and then ejects the seat. As the seat moves up the guiderails, emergency oxygen is supplied, IFF is turned on, personnel services (airplane oxygen and communication) are

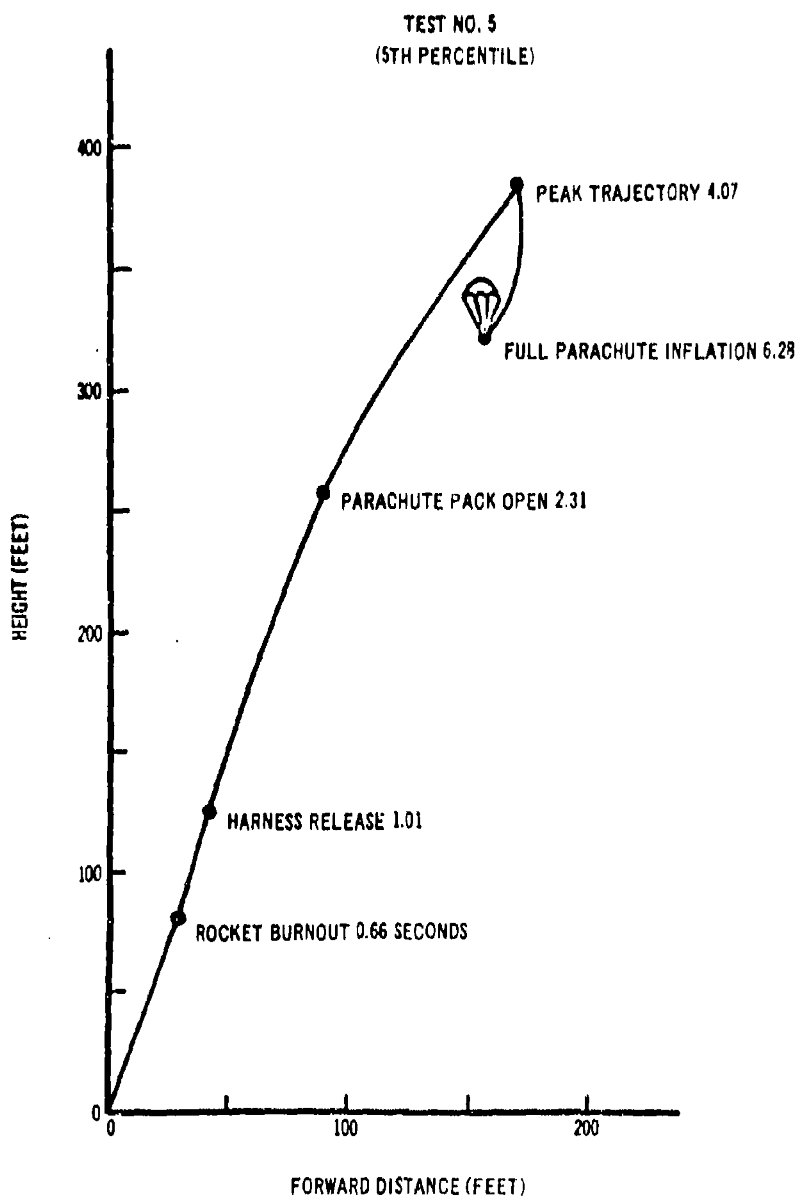


Figure 12. Douglas Escapac IC Seat Trajectories for Zero-Zero Condition With 5th Percentile Crewman

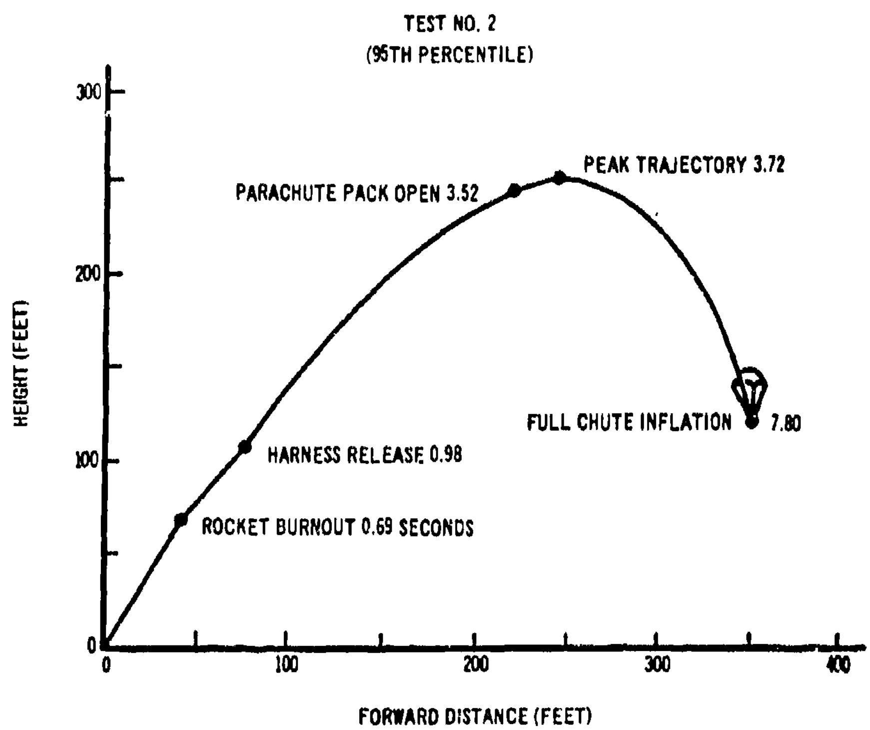


Figure 13. Douglas Escapac IC Seat Trajectory for Zero-Zero Condition With 95th Percentile Crewman

disconnected, the seat stabilization parachute release mechanism is armed, the personnel parachute drogue gun is actuated, the pitch stabilization system rate gyro is brought up to speed, and the pitch system vernier rocket motor is ignited. As the seat clears the top of the guide rails, the rocket motor ignites, the seat stabilization chute is deployed, and the vernier rocket motor is rotated by its rate gyro to provide a stabilizing moment, as required. After a predetermined time delay, an aneroid controlled initiator releases the pilot's restraint harness and fires the parachute deployment gun if, or when, below 10,000 feet. The mortar reaction force is transmitted directly to the seat structure, providing positive man-seat separation. Because of the man-seat weight ratio and the direction of the mortar reaction load and stabilization chute drag, the seat is deflected away from the man, eliminating seat-man-parachute collision or entanglement. At full-line stretch, a deployment bag strips away from the 28-foot diameter flat circular canopy parachute, allowing aerodynamic inflation. A typical ejection event-time sequence is as follows:

Event	Time (Seconds)
• Firing control actuated, ballistic inertia reel actuates, catapult fires (0.04 second delay)	0.0 0.40
• Seat clears top of guide rails (0.14 second), rocket motor ignites, stabilization chute drogue gun fires.	0.54
• Rocket motor burns out, drogue chute becomes effective.	1.08
• Harness release actuator fires (if below 10,000 feet), personnel parachute drogue gun fires.	2.40
• Parachute is fully inflated (for high-speed ejections below 10,000 feet the time for full parachute inflation would be reduced to approximately 4.0 seconds).	5.60

The overall installation dimensions of the Escapac II seat are the same as Escapac IC, however, the weight of the system is slightly increased as shown in Table III.

The major improvements incorporated into the Escapac II system are as follows:

The back-headrest assembly is contoured for comfort and optimum support of the crewman during airplane catapulting, aerial maneuvers, ejection loads, and parachute landing. The assembly also provides stowage for the face curtain firing control and retention of the personnel parachute. During

Table III. Douglas Escapac II Seat Weight Breakdown

	Installed Weight (Lbs)	Ejectable Weight (Lbs)
Seat assembly (including drogue)	50.5	50.5
Stabilization system (STAPAC)	6.5	6.5
Backrest assembly	13.0	13.0
Power inertia reels and controls	2.9	2.9
Parachute assembly	19.0	19.0
Survival kit (including emergency oxygen)	39.0	39.0
Rocket catapult assembly	18.3	12.7
Electromechanical seat actuator	5.0	0
Accessories	12.0	0
Total	166.2	143.6

normal flight conditions, the back-headrest assembly is firmly attached to the seat structure, allowing the pilot to lean forward with only the weight of the shoulder straps offering any resistance to movement. During ejection or manual egress from the cockpit, the back-headrest assembly is released automatically from the seat structure and is secured to the pilot's back by the power takeup reel.

The mortar deployed parachute assemhly consists of a standard flat circular 28-foot canopy, pilot chute, deployment bag, and a mortar. The mortar utilizes a cartridge incorporating dual firing pins and primers. It has an inner and outer tube; the inner tube is attached to the seat structure behind the back-headrest, and the outer tube is secured in a vertical position in the center of the packed parachute. The parachute assembly is installed in a supporting pouch on the aft side of the back-headrest, and the entire assembly is slid down over the inner tube and secured to the seat structure. During the escape sequence, if the harness release mechanism fails, the personnel parachute will deploy and recover the pilot and seat as a unit.

The ballistic takeup inertia reel operates to properly position and restrain the pilot in the seat prior to ejection. By positively positioning the pilot, rocket-thrust-center of gravity eccentricity can be controlled, resulting in increased seat-man stability and trajectory height.

Stabilization of the seat-man is accomplished by the DART (Directional Automatic Realignment of Trajectory) and drogue chute systems. A slipline, attached to the airplane, is routed through a bridle arrangement and brake assembly installed on the seat. If the CG-thrust alignment induces rotation of the ejected mass, automatic correction is supplied by DART limiting the system rotation at rocket burnout to a preprogrammed value. The 42-inch diameter ribless guide surface drogue chute, installed on the seat back, is utilized to ensure proper seat attitude for ballistic parachute operation, and to provide stability and velocity decay for high-speed ejection. A four-point bridle geometry is utilized with two attachments located near the bottom seat rollers and two on the upper roller shafts. Initiated by a striker plate arrangement, the drogue gun fires just before the seat leaves the rails, propelling the slug upward and aft at an initial angle of 30 degrees relative to the seat back structured. The lower risers are encased in a neoprene rubber extrusion to prevent burn damage from the rocket catapult. Additional protection from burn damage is afforded by a special pounch-like container that prevents the risers from prematurely dropping down into the rocket wake.

Provisions for over-the-side bailout is retained in Escapac II. The harness release handle, located on the right-hand side of the seat bucket, is used for this purpose. It is also used in ditching escape situations and in normal servicing and parachute repacking procedure. Actuation of the handle releases the lap belt and back-headrest, and disengages the parachute mortar from the seat structure. As the pilot stands up in the cockpit, he is entirely free of the seat. A D-ring on the left-hand riser is pulled after bailout to deploy the parachute. For normal egress the parachute and survival kit are removed by releasing the four GFAE disconnect fittings located on the riser and lap belt. If it is desired to retain the survival kit, only the two top fittings on the parachute risers are released.

The Douglas Company is continuing an in-house Escapac II development program to improve system capability during high sink rates and adverse airplane attitudes. Dynamic testing is also being accomplished to improve and advance the stabilization and recovery systems to enhance low-level escape capability.

d. LOCKHEED C-2 SEAT

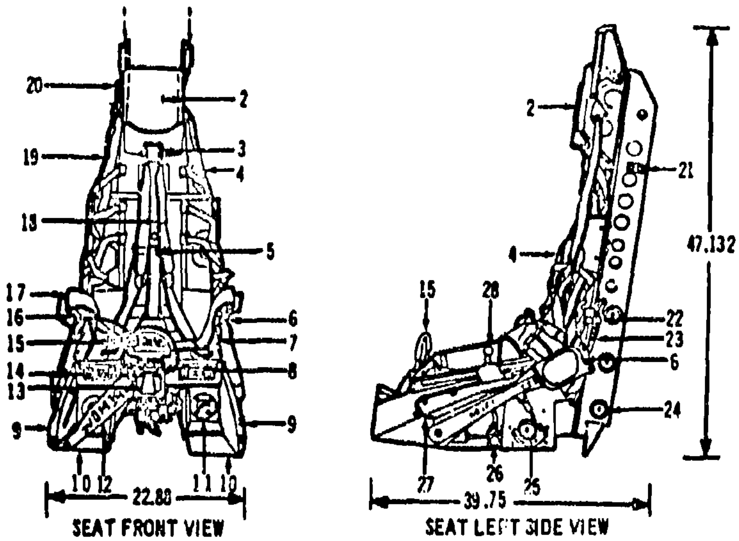
The Lockheed C-2 upward emergency ejection seat system was developed for use in the F-104 airplanes. The system desribed here applies to the F-104B and F-104D airplanes, and is similar to all F-104 escape systems currently in service.

The system is completely automatic after being intiated by pulling the D-ring located on the forward edge of the seat bucket. Upon initiation, the canopy is jettisoned during the time the crewman is restrained in the seat prior to catapult firing. If the canopy fails to jettison, the seat is safely ejected through it. The forward and aft seats are similar but not interchangeable. Seat differences, however, are of a minor nature and have no effect on the overall seat system or its operation. The differences are the canopy breakers, anti-g and vent suit disconnect coupling, and arm net fitting assembly located at the outer end of the leg guards. The different configurations of the canopy breakers are a result of the variations of seat-to-canopy clearance of the two cockpits. The differences in the anti-g and vent suit disconnect coupling and arm net fitting assemblies are the result of the aft cockpit being narrower than the forward cockpit.

The C-2 seat incorporates the following design features:

- Single D-ring control which operates all seat primary and secondary systems with one motion.
- Positive automatic foot retraction and retention system.
- Automatic erecting leg guards.
- Automatically deployed arm support webbing.
- Automatic lap belt release and foot retention separation.
- Auxiliary manual control for pilot foot retention separation. (The primary purpose of the auxiliary manual control on the C-2 seat is for use by ground rescue personnel in separating or releasing the pilot's feet in an emergency situation.)
- Positive automatic pilot-seat separation device.
- Survival kit and positive pilot-kit separation system.
- Dual oxygen system; diluter demand for under 42,000 feet flight altitude and high pressure for over 42,000 feet flight altitude.

Installation dimensions and basic components of the ejection seat system are shown in Fig. 14 (Ref. 1). The ejection sequence, including the ballistic items currently used in the system, are shown in Fig. 15. When the D-ring is pulled, the first M27 (T25) initiator operates the canopy primary jettison system by firing the M13 (XM13) canopy latch release thruster. The



1 CANOPY BREAKER
2 HEADREST
3 INERTIA REEL STRAP
4 ARM NET OR RETENTION WEBBING
5 ROTARY ACTUATOR STRAP (PILOT-SEAT SEPARATION)
6 LEG GUARD (TYP 2 PLACES)
7 SEAT BUCKET
8 SEPARATION HARNESS STRAP PIN (TYP 2 PLACES)
9 STIRRUP
10 FOOT RAMP
11 FOOT RETAINER BALL ASSEMBLY
12 D-RING SAFETY PIN STREAMER
13 D-RING CABLE GUARD
14 D-RING SAFETY PIN
15 D-RING
16 LAP BELT HOSE ASSEMBLY
17 MA-6 LAP BELT
18 SHOULDER HARNESS
19 DILUTER DEMAND OXYGEN HOSE STORAGE ASSEMBLY
20 AUXILIARY CABLE CUTTER HANDLE
21 SPACER OR RUB BLOCK (TYP EACH SIDE)
22 SEAT DISCONNECT
23 WIRE HARNESS (SWITCH TO SEAT DISCONNECT)
24 SEAT ROLLERS (TYP 6 PLACES)
25 FOOT RETRACTION REEL PULLEY (RATCHET)
26 CABLE CUTTER (TYP EACH SIDE)
27 CABLE (LEG GUARD TO INERTIA REEL MANUAL LOCKING HANDLE)
28 INERTIA REEL LOCK HANDLE

Figure 14. C-2 Ejection Seat System, Forward Cockpit

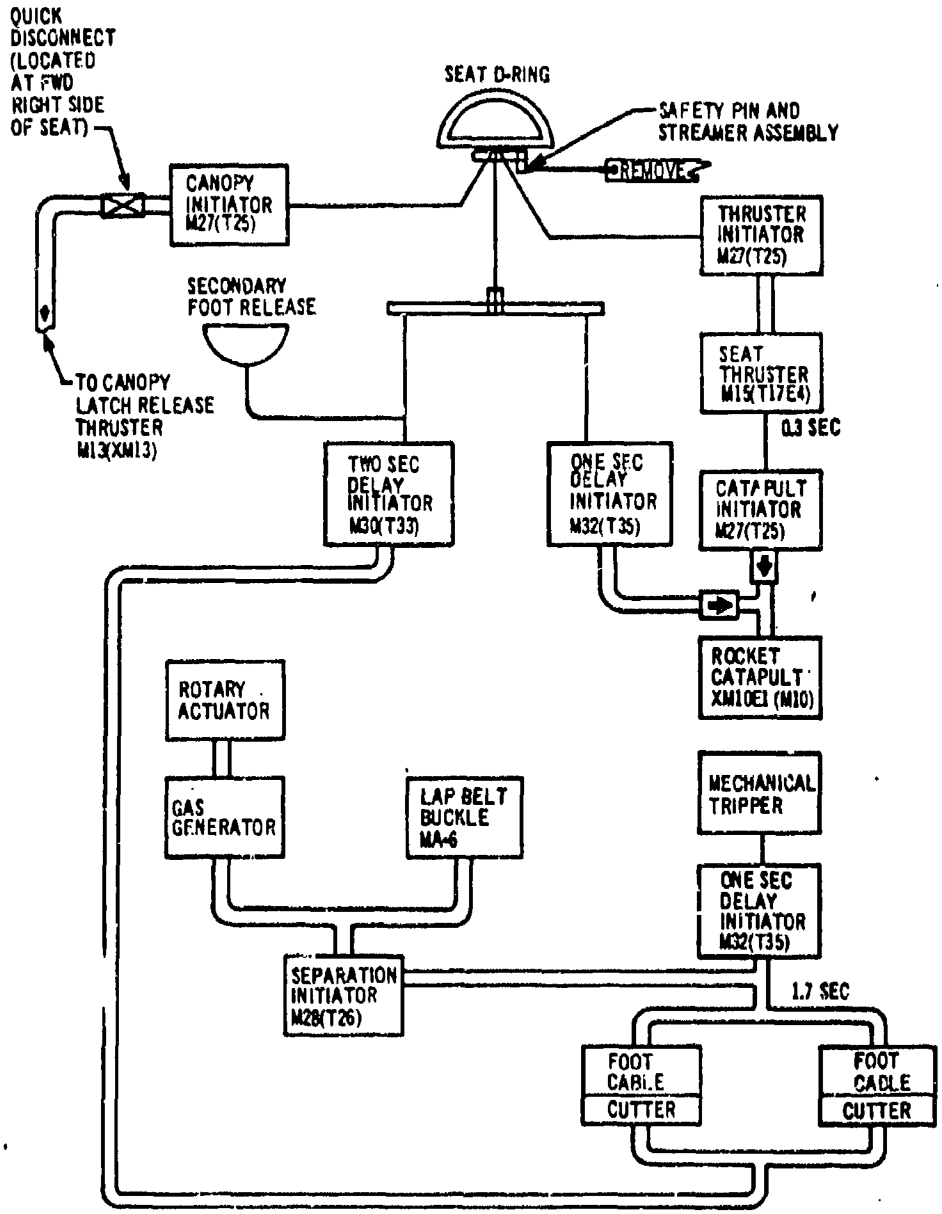


Figure 15. C-2 Ejection Seat Sequence, Forward and Aft Cockpit Schematic

second M27 (T25) initiator fires the M15 (T17E4) thruster, which deploys the leg guards and arm webbing, locks the inertia reel, and retracts the pilot's feet. As the leg guard torque tube rotates to the deployed position, mechanical linkage is actuated, firing the third M27 (T25) initiator, which fires the XM10E1 (M10) rocket-catapult. As the seat moves up the rails, a trip lever fires an M32 (T35) one-second delay initiator, which operates one side of the foot retraction cable cutters and fires an M28 (T26) initiator. The M28 (T26) initiator operates the lap belt and fires the gas generator that operates the rotary actuator separating the pilot from the seat. Just prior to the end of the travel of the D-ring an M32 (T35) one-second delay initiator and an M30 (T33) two-second delay initiator are fired. The M32 (T35) initiator is a backup for the rocket-catapult initiator, and the M30 (T33) initiator operates the secondary side of the foot retention cable cutters. The same M30 (T33) initiator may be fired by pulling the manual cable cutter handle located to the right of the headrest. It should be noted that the secondary system provides complete backup for the primary system and results in increased system functioning reliability.

The parachute and survival systems are actuated as the seat moves up the fixed rails. Lanyard action releases the survival kit disconnect, causing the airplane oxygen supply to be cut off, the emergency oxygen system to be turned on, the life raft CO_2 bottle arming device to be activated, and the survival kit armed (locked to the parachute attachment). For very low altitude ejections, the parachute will open almost instantly (zero lanyard); however, if ejection occurs at high altitude, the parachute will be activated by an aneroid control at approximately 15,000 feet altitude. During descent, the survival kit handle can be raised to release the right and left parachute attachments, unlock the front compartment cover (container can now separate and fall free), release the kit-to-man oxygen quick disconnect, and actuate the CO_2 bottle to inflate the life raft.

Table IV gives the C-2 seat weight breakdown.

Table IV. Lockheed C-2 Ejection Seat Weight Breakdown

	Weight (Lb) Installed	Weight (Lb) Ejectable
Seat assembly	102.13	102.13
Rocket-catapult XM 10	26.00	15.00
Pyrotechnics inst — seat	14.17	14.17
Actuator, seat adjustment	8.70	---
Seat rails, support structure, and brackets	41.60	---
Clothing, shoes, helmet, and personal equipment	45.00	45.00
BA-15 parachute pack with timer	28.75	28.75
Total Weight	266.35	205.05

Table IV. Lockheed C-2 Ejection Seat Weight Breakdown (Cont)

5th Percentile dummy	132.5 pounds
50th Percentile dummy	161.9 pounds
95th Percentile dummy	200.8 pounds

An extensive test program was conducted on the C-2 escape system at the Hurricane Supersonic Research Site in Utah from July 1959 through March 1960. The seat was ejected at various sled speeds, and although zero speed-zero altitude capability was not a requirement, four static ejections were performed. Two of these were through the canopy to evaluate this emergency condition.

Results of the static ejection tests are as follows:

Test Number	Date	Ejected Wt (Lb)	Top of Trajectory (Ft)	Type of Actuation	Pilot Chute	Quarter Bag
S-12	8 July 1959	365	230	Zero Lanyard (1 and 0)	Std 36"	Yes
S-13	8 July 1959	391	215	Zero Lanyard (1 and 0)	Std 36"	Yes
S-18	18 March 1960	334	182	(1 and 1)	Lge 44"	Yes
S-19	18 March 1960	401	175	(1 and 1)	Lge 44"	No

Test Notes

- All the tests were conducted using the standard U.S. Air Force BA-15 (P/N 50C7024-15) parachute pack with the C-9 (28-foot flat circular) canopy.
- S-18 and S-19 — These ejections were successfully accomplished through the cockpit canopy.
- S-12 — The parachute D-ring hung up in its pocket; however, it was finally pulled below the Mesa level and the chute deployed and fully inflated prior to ground contact.
- S-13 — The seat-dummy did not separate due to a faulty hose in the ballistic system.

- S-18 — The parachute risers were not tied down in the pack, and the parachute was fully inflated 55 feet above the ground.

- S-19 — The parachute risers were not tied down in the pack, and the parachute was fully deployed at 7 feet above the ground but not inflated.

Due to the successful recovery during test S-18, it was apparent that an operational zero-zero escape system was possible. Therefore, industry effort was accelerated to improve the low-speed, low-altitude capability of all existing escape systems.

Test trajectories are shown in Fig. 16 for various speeds throughout the operating range of the F-104 airplane. The system capability has been established by sled and flight tests and has also been proved during in-service emergency escapes. Figure 17 shows the standard C-2 escape system capability envelope, using the XM 10E1 rocket-catapult.

The continued design improvement effort by Lockheed to advance the capability of the C-2 ejection seat resulted in the development of a zero-zero escape system (Ref. 2). Recovery capability at zero-speed and zero-altitude with the current production version of the C-2 seat was made possible by the development of a new rocket catapult (RPI 2174-14). This rocket motor develops approximately 60 percent more total energy than the original motor, fits in the same space envelope, and does not materially increase the g-forces during operation.

Other system improvements were: 1) providing for positive detachment of the pilot's personal (oxygen and communication) leads by a cable attached to aircraft structure during seat ejection and by substitution of a more effective rotary actuator; 2) automatic arming of the F-1B parachute opening timer was made more positive, accomplished by shortening the timer arming lanyard from 20 to 10 inches and by reversing the lap belt so the lanyard (attached to the right belt) would be pulled by the initial movement of the pilot separating from the seat; 3) requirement for the zero-delay lanyard was eliminated; and 4) deployment and inflation of the P9B4 parachute system, that had been uncertain and irregular under low-speed conditions, were rendered positive and consistent by modification in the area of the quarter bag. The quarter bag was modified by removing some stitching and thereby enlarging the opening through which the skirt of the main canopy is released. Closure was effected by installing another set of locking loops, to be locked by a bight in the shroud lines.

This improved system was successfully demonstrated by a static ejection test on June 5, 1963. A comparison of the improved and original C-2 escape system trajectories is shown in Fig. 18. The improved system peak trajectory was in excess of 400 feet, and full canopy inflation occurred 290 feet above the ground. The trajectory height represents a 100 percent increase over the maximum height attained with the original C-2 seat rocket catapult (XM 10E1).

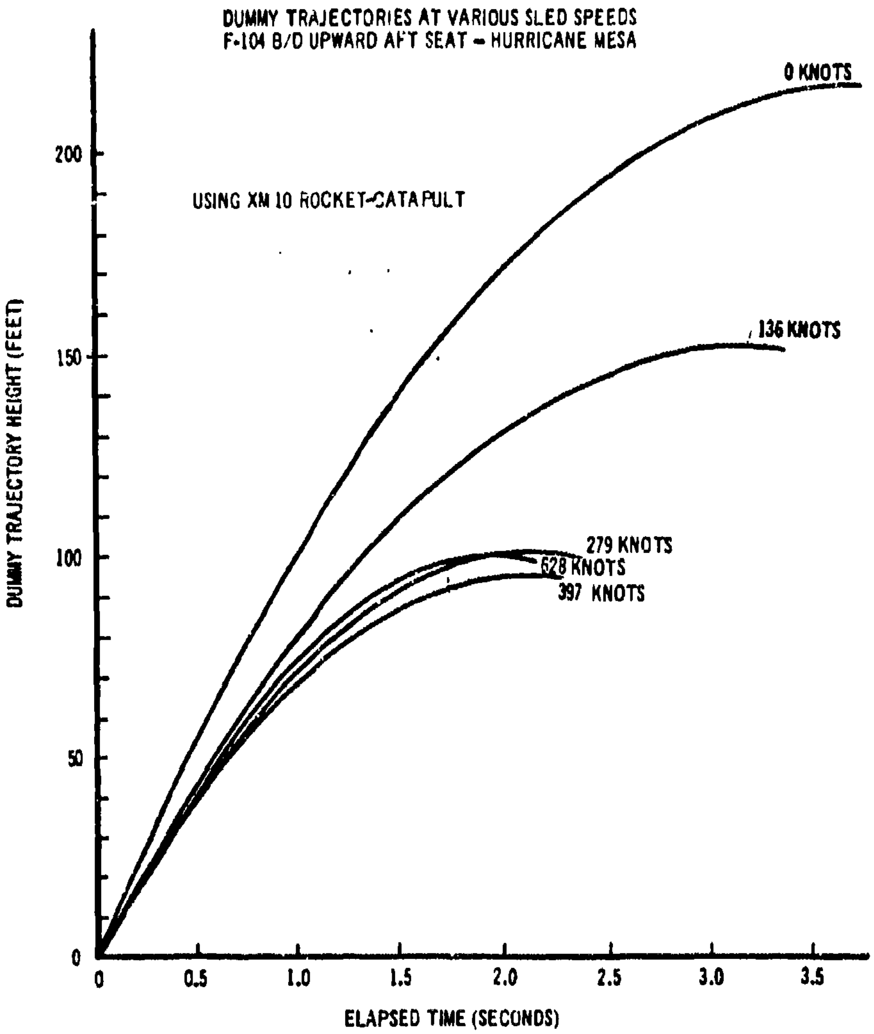


Figure 16. C-2 Ejection Seat Maximum Height Test Trajectories

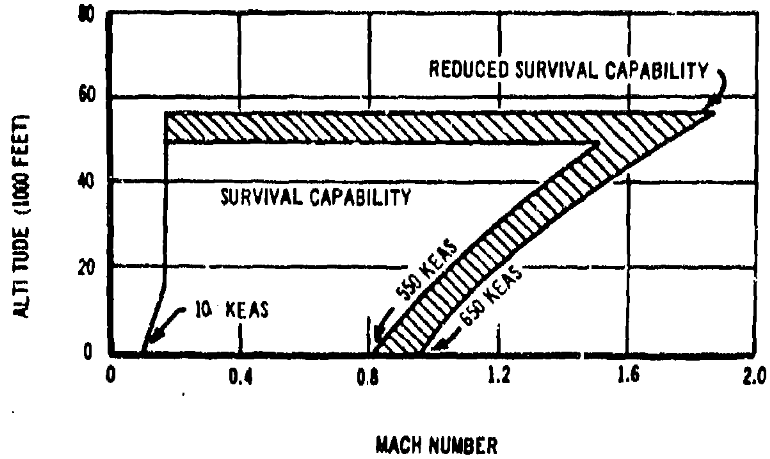


Figure 17. C-2 Ejection Seat System Capability

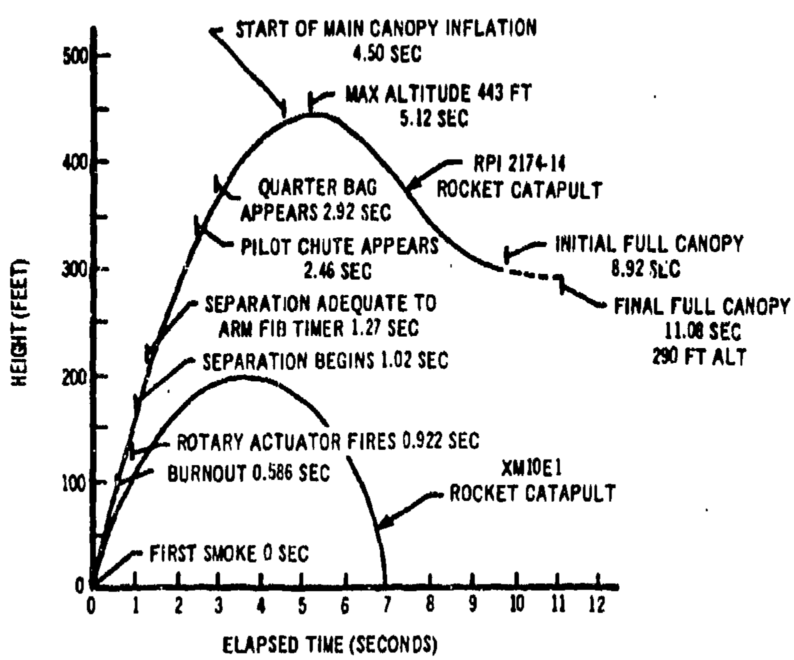


Figure 18. C-2 Ejection Seat Static Ejection Test – Rocket-Catapult Comparison

e. MARTIN-BAKER SEAT

The Martin-Baker MK-GRU-5 ejection seat system installed in the Navy (Grumman-Intruder) Model A-6A provides safe escape at ground level (with a minimum speed of 100 knots) and throughout the entire speed and altitude range of the aircraft.

The system's major subsystems and components are: 1) ejection gun with a primary and two secondary catapult charges, 2) ballistically deployed duplex drogue parachute system (controller and stabilization chutes), 3) leg and body harness restraint system, 4) automatic g-controller in the personnel parachute system, and 5) survival kit and equipment. The seat is also provided with screw type electromechanical actuators for vertical and tilt adjustments. The maximum vertical travel range is approximately five inches, and the seat can be tilted to any angle through a maximum travel range of ten degrees. The seat and components are shown in Figs. 19 and 20.

The Martin-Baker escape system has been used in nearly 20 types of U.S. aircraft and is in service with aircraft in 35 nations throughout the world. Approximately 400 successful ejections have been recorded over speed ranges up to Mach 1.7 at 40,000 feet and at altitudes from ground level to 56,000 feet. The system is currently used in the following U.S. aircraft: TF9J, AF9J, F-11A, AO-1, A-6A, AF-1E, F-6A, F-3C, F-4B, F-8A, RF-8A, F-8B, and T-1A.

Emergency escape from the A-6A airplane is normally accomplished by ejecting through the canopy glass; however, if time permits and the airspeed is below 200 KEAS, the canopy can be jettisoned. There is no interlock mechanism in this aircraft between the ejection seat and the canopy jettison system. Jettisoning of the canopy must be accomplished as a separate function prior to catapult initiation. Ejection sequence for low and high-altitude escape conditions are shown in Figs. 21 and 22, respectively.

Once the escape system is initiated, the sequence of operation is completely automatic; however, provisions are made allowing the seat occupant to manually override the events necessary for safe recovery. The sequence of operation is as follows:

(1) Initiation is accomplished by pulling the face curtain (primary firing control) or the seat D-ring (secondary firing control) which fires the primary ejection gun cartridge.

(2) Initial vertical g-loads imposed during start of ejection locks the harness restraint mechanism.

(3) Seat movement up the rails causes the following events:

(a) Pulls in and retains the occupant's legs against the forward face of the seat bucket, through the action of the leg restraint mechanism.

(b) Drogue gun and time release mechanisms are armed.

1. FACE CURTAIN SAFETY PIN
2. FACE CURTAIN LOCK
3. HEAD REST
4. TOP LATCH MECHANISM
5. UPPER RESTRAINT HARNESS ROLLER YOKES (2)
6. DROGUE GUN
7. DROGUE GUN SAFETY PIN
8. PERSONNEL PARACHUTE D-RING
9. DROGUE GUN TRIP ROD
10. VENTILATED BACK PAD
11. ANTI-G HOSE
12. VENT AIR HOSE
13. PERSONNEL SERVICES DISCONNECT (ANTI-G AND VENT AIR)
14. LOWER RESTRAINT HARNESS (LAP BELT) ADJUSTOR (2)
15. HARNESS INERTIA LOCKING MECHANISM CONTROL HANDLE
16. LEG LINE SNUBBER AND PERSONNEL SERVICES DISCONNECT RELEASE LEVER
17. THIGH SUPPORT
18. LEG RESTRAINT CORDS
19. SECONDARY FIRING CONTROL GUARD SAFETY PIN
20. SECONDARY FIRING CONTROL LOCK GUARD
21. SECONDARY FIRING HANDLE
22. LAP BELT (LOWER RESTRAINT HARNESS)
23. OXYGEN (COMMUNICATION) HOSE

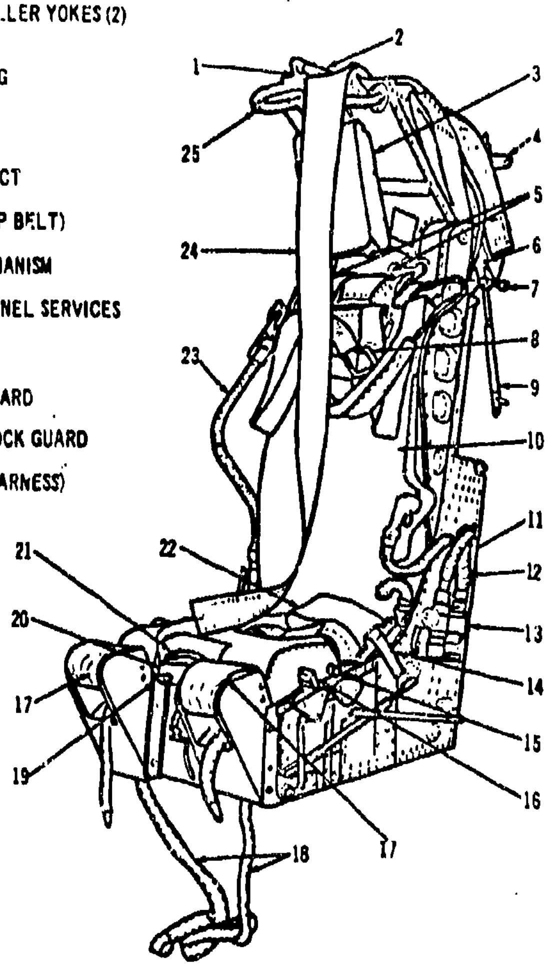


Figure 19. Martin-Baker MK-GRU-5 Ejection Seat

24. GROUND SAFETY LOCK FLAG (RED RIBBON)
25. FACE CURTAIN HANDLE (PRIMARY FIRING CONTROL)
26. UPPER RESTRAINT HARNESS ROCKET JET FITTING (2)
27. VENTILATED SEAT PAD
28. SECONDARY FIRING CABLE HOUSING
29. SEAT HEIGHT ADJUSTMENT SWITCH
30. SEAT TILT ADJUSTMENT SWITCH
31. MANUAL OVERRIDE LEVER
32. OXYGEN REGULATOR
33. OXYGEN REGULATOR CONTROL VALVE
34. EMERGENCY OXYGEN MANUAL CONTROL
35. PERSONNEL SERVICES DISCONNECT (OXYGEN AND COMMUNICATIONS)
36. EMERGENCY OXYGEN BOTTLE
37. TIME RELEASE MECHANISM TRIP ROD
38. TIME RELEASE MECHANISM
39. SHACKLE RELEASE PLUNGER ASSEMBLY
40. CANOPY BREAKER POINT (2)

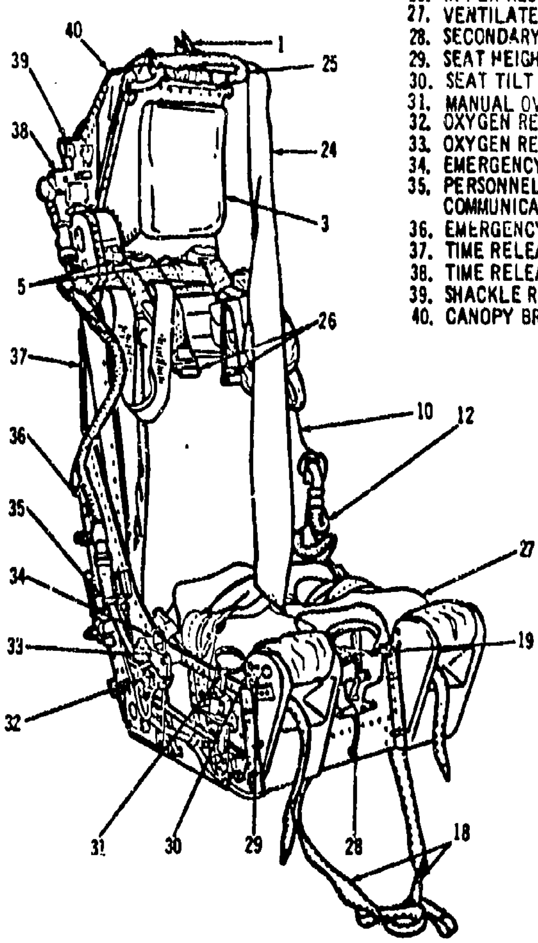


Figure 20. Martin-Baker MK-GRU-5 Ejection Seat

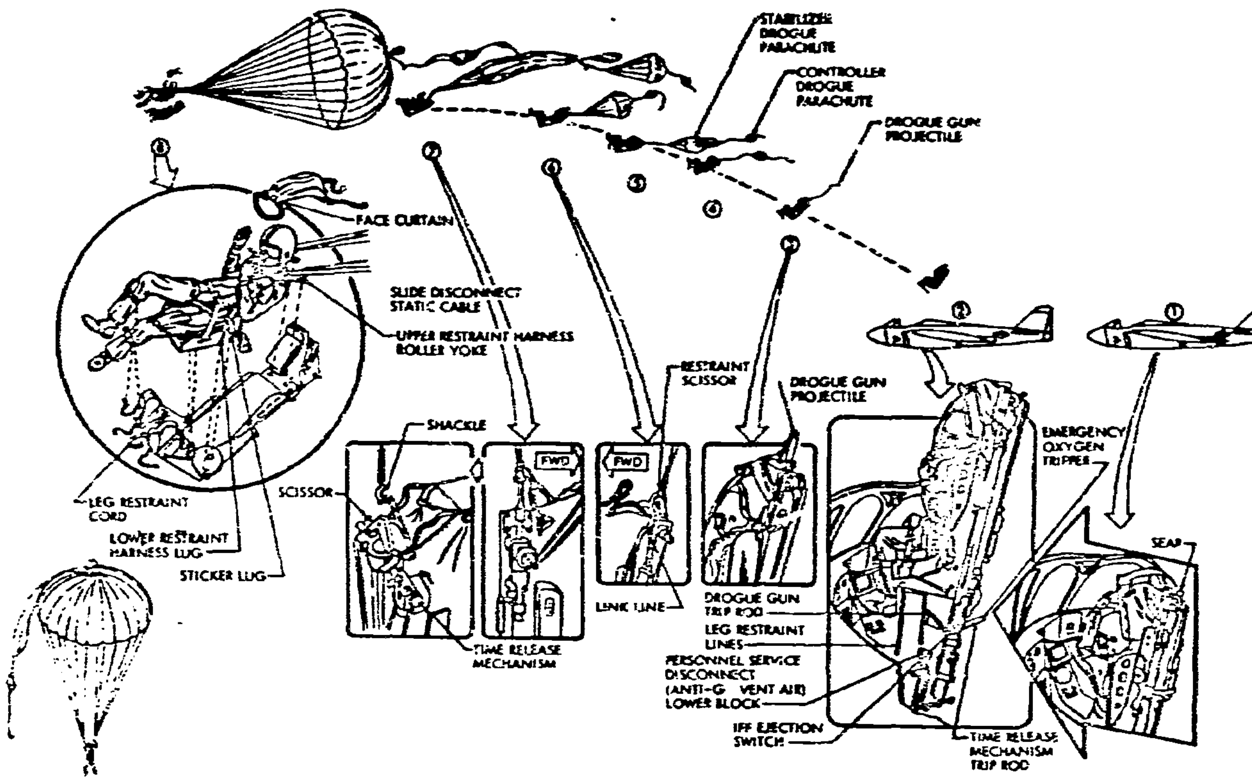


Figure 21. Martin-Baker Ejection Sequence (Below 10,000 Feet)

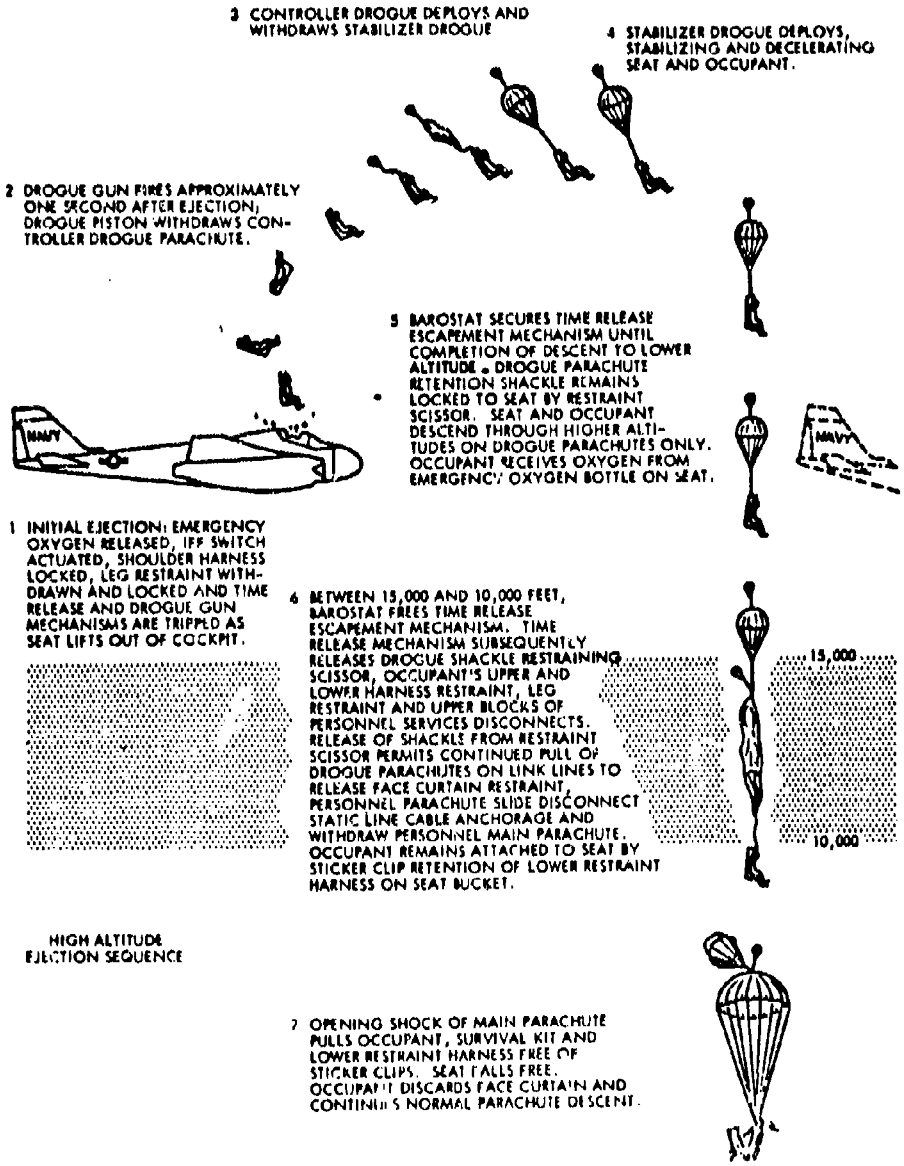


Figure 22. Martin-Baker Ejection Sequence (Above 15,000 Feet)

(c) Emergency oxygen supply is activated.

(d) Personnel services (anti-g, vent air, oxygen, and communication) disconnects are pulled free.

(e) The emergency channel of the IFF system is activated.

(4) Approximately 1 second after ejection the drogue gun fires, deploying the 22-inch controller chute which positions in the slipstream and withdraws the 5-foot stabilizer parachute. The stabilizer drogue, attached to the seat by the locked restraint scissor mechanism, decelerates and stabilizes the seat.

(5) After vertical (spinal) deceleration has been reduced to between 3 to 4.5 g at an altitude below 15,000 feet, the time release mechanism begins a 1.65 to 1.85 second delay prior to operating and performing the following actions:

(a) Actuates shackle release plunger, allowing the drogue parachute restraint scissors to open and free the drogue parachute shackle from the seat. The pull of the drogue parachutes releases the face curtain restraining straps, the personnel parachute slide disconnect static line cable anchorage, and withdraws the personnel parachute from its container.

(b) Actuates the harness release mechanism lever releasing the upper and lower restraint harness anchorage, the personnel parachute restraint straps, and ejects the upper block of both seat-mounted personnel services disconnects and both leg restraint cords.

(6) The fully inflated personnel parachute pulls the occupant and survival kit free of the sticker clip retention, ensuring clean separation of the occupant and seat.

Sufficient system testing has been accomplished by NACEL to ensure safe escape throughout the A-6A performance envelope. However, results of the testing accomplished on this system are not available for inclusion in this document.

The sticker clips and ejection gun used in the system are unique and function as follows: The sticker clips are mounted on the inboard side of each seat bucket sideplate to retain a lug attached to the occupant's lower restraint harness. As a result of the sticker clip spring action on the harness sticker strap lug, the occupant will be retained in the seat until the opening shock of the personnel parachute pulls the occupant's harness free of the sticker clips. This ensures clean separation and eliminates the possibility of collision between the occupant and the seat.

The ejection gun consists of three telescoping tubes, a primary explosive cartridge, two identical auxiliary explosive cartridges, and a firing mechanism. Operation of the firing mechanism causes a firing pin to detonate the primary cartridge and raise the seat away from the cockpit floor. The

lower and upper auxiliary cartridges are fired after 14 and 17 inches of seat travel, respectively, and assist in ejecting the seat and occupant from the aircraft. The ejection gun has two guide rails (channels), one on either side. These rails function as tracks for six slippers (three on each side) attached to the inside of the seat main beam assembly. The slippers and guide rails guide and align the seat during ejection and also during normal removal and installation. The ejection gun cartridges will operate satisfactorily at a temperature range between -65°F and +160°F.

The Aerospace Crew Equipment Laboratory has conducted a test program to compare the performance of the Martin-Baker Mark 5 ejection seat utilizing the Martin-Baker seat pan rocket system and the Rocket Power, Inc. seat back rocket system. The RPI system consists of two rocket catapults, and the M-B system consists of a catapult and a separate rocket system utilizing 18 propellant tubes that fire into a manifold with six thrust nozzles. Photographs of the seat and rocket systems are shown in Figs. 23, 24, and 25. Also, evaluated in the tests was the Northrop Duplex Drogue and Skysail parachute system.

Seven sled ejection tests were run on each system at approximately 0, 50, 400, and 600 knots IAS using 5 and 95 percentile dummies at each speed (except the 600-knot test which was run with only a 5 percentile dummy). All tests were considered successful except the 600-knot tests, during which the following failures were encountered: 1) the Skysail parachute did not fully inflate due to insufficient trajectory height for zero-altitude recovery, and 2) the g-loads measured were beyond the accepted human tolerance limits. Test trajectory data shown in Figs. 26 through 29 are the time-sequence of events versus altitude for the 0- and 400-knot tests. Testing indicated the RPI rocket catapult system performance to be slightly superior to the M-B system; however, both systems were considered adequate for use with the Martin-Baker Mark 5 ejection seat.

The Northrop-designed duplex drogue (22-inch drogue and 5-foot deceleration parachute) and 29.7-foot Skysail parachute system performed satisfactorily throughout the test program. This parachute system can be opened safely at higher speeds, eliminating the need for the g-limiter device.

f. NORTH AMERICAN X-15 EJECTION SEAT

The X-15 research airplane is designed to explore the space flight regime and to investigate the high load factors imposed by the accompanying exit and re-entry phases. Paramount consideration was given to pilot protection from the adverse pressure and thermal environment and to pilot motor abilities while subjected to highly transient force systems. An extensive survey of escape-system types indicated that an open ejection seat in conjunction with a full-pressure protective garment best satisfied the emergency escape requirements.

The X-15 ejection seat is capable of providing safe escape at speeds up to approximately 700 KEAS at pressure altitudes from sea level to 60,000 feet, and up to Mach 4.0 at altitudes from 60,000 to 120,000 feet. Ground-level escape is provided for level flight conditions at speeds between 90 and 200 KEAS.

Figure 23. Martin-Baker MK-GRU-5 Ejection Seat with RPI Rocket-Catapult System

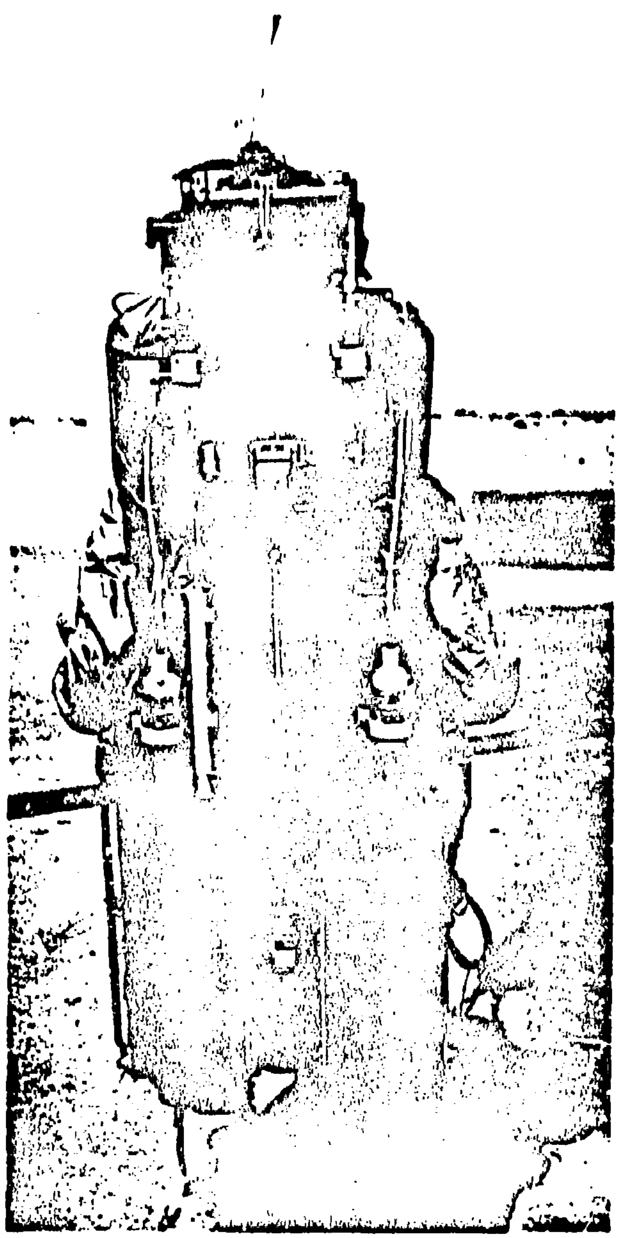


Figure 24. Martin-Baker MK-GRU-5 Ejection Seat with RPI Rocket-Catapult System

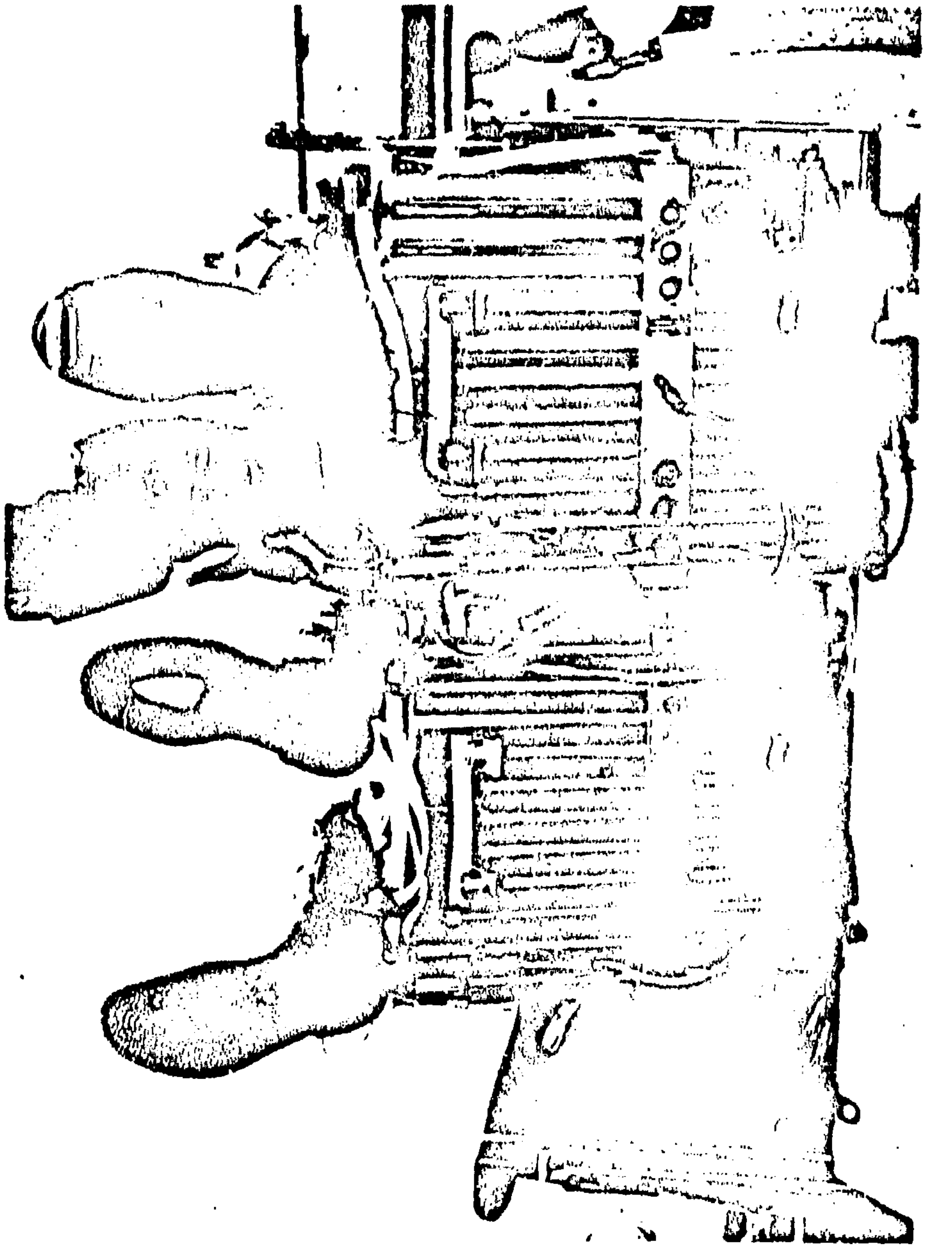


Figure 25. Martin-Baker MK-GRU-5 Ejection Seat with MB Seat-Pan Rocket System

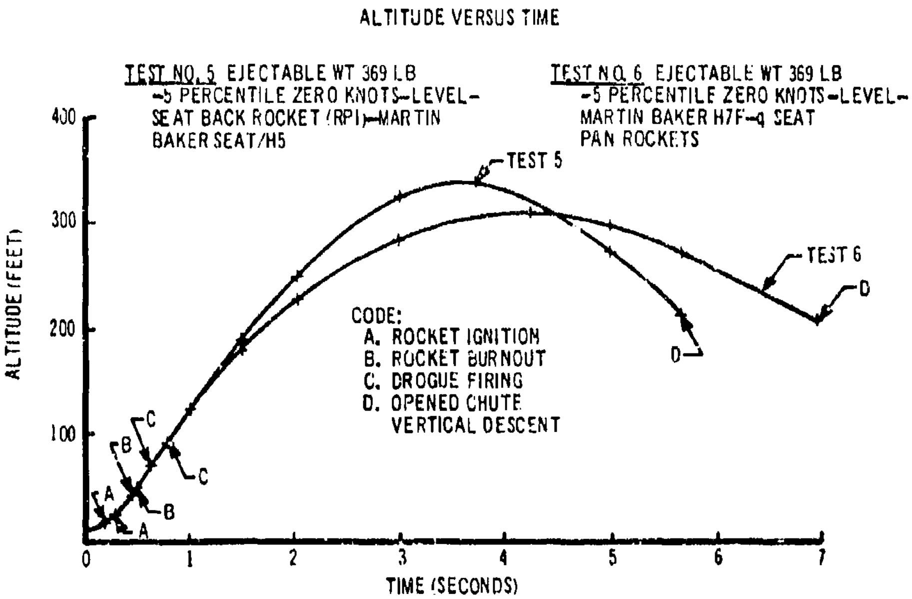


Figure 26. Martin-Baker MK-GRU-5 Sled Ejection Tests

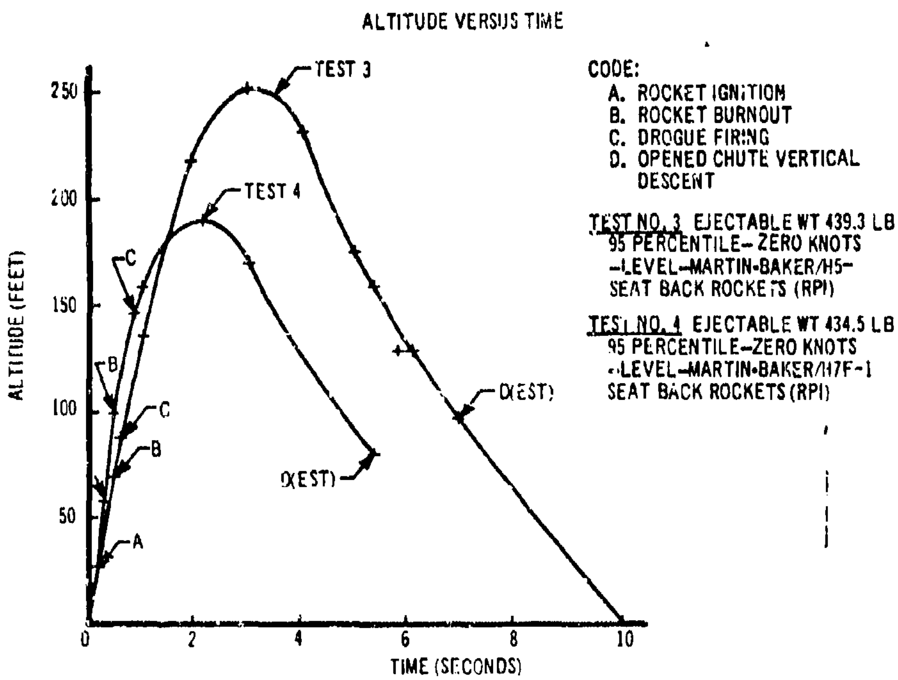


Figure 27. Martin-Baker MK-GRU-5 Sled Ejection Tests

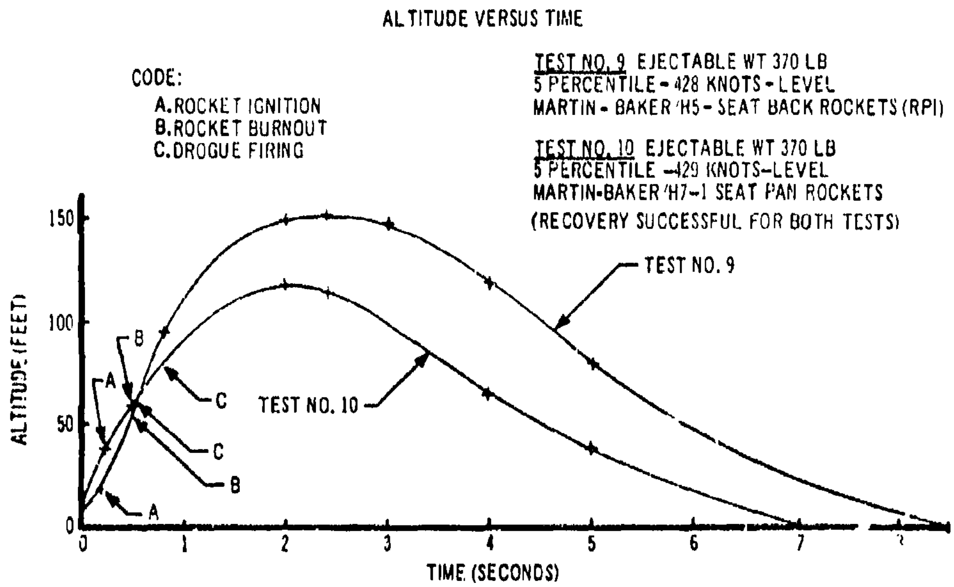


Figure 28. Martin-Baker MK-GRU-5 Sled Ejection Tests

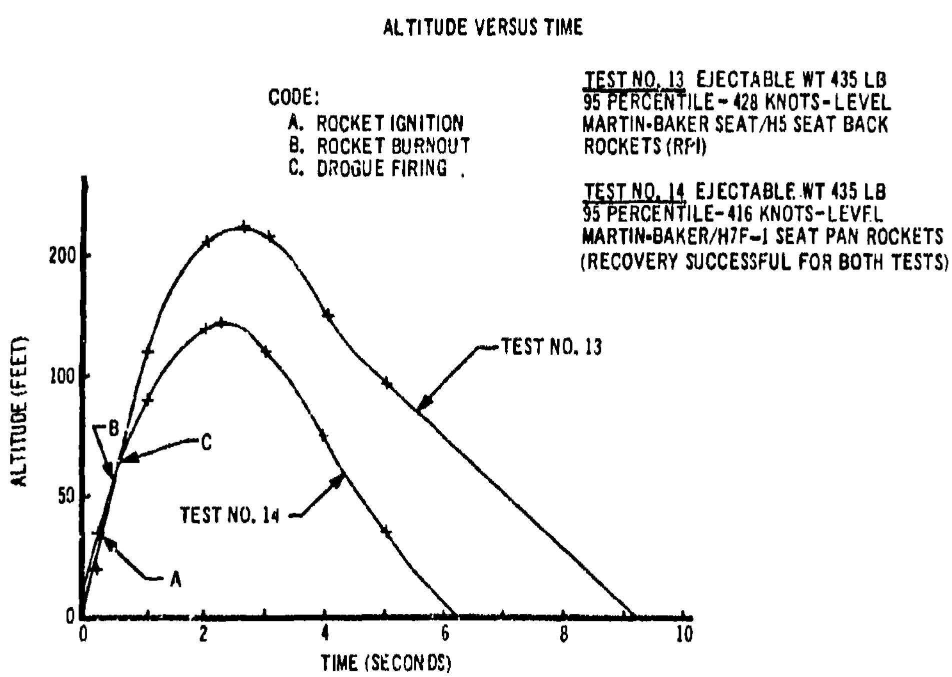


Figure 29. Martin-Baker MK-GRU-5 Sled Ejection Tests

The pressure suit provides pilot protection from aerodynamic heating, reduced pressure levels, and windblast. A study of accident potential for the X-15 maximum effort mission indicated, as shown on Fig. 30, that the escape system capability includes 98 percent of the airplane accident potential. It was concluded that the 2 percent of accident potential not included can best be countered by occupying the airplane until the severe flight conditions have been relieved.

The X-15 escape system is composed of an open ejection seat, oxygen system, A/P 225-2 pressure suit, pilot restraint system, rocket catapult, fin and boom stabilization system, and personnel parachute recovery system. The general arrangement of the escape system is shown in Fig. 31.

Emergency escape from the airplane is accomplished in the following manner and is shown in the block diagram Fig. 32. After electing to abandon the air vehicle, the pilot manually converts to the emergency oxygen supply by pulling a lanyard attached to the back-pack valving and manifold assembly. The procedure is a precautionary measure, since the conversion is included as an automatic feature during seat and pilot separation. After conversion of the oxygen supply, the pilot kicks aft on the manacle restraint assemblies on each footrest, thereby securing the feet and lower limbs. At the same time, both ejection control release levers are squeezed and the handgrips rotated upward and inboard. Movement of either handle will initiate the ejection sequence, although both should be operated since they also function as hand restraints and are responsible for displacing the armrests inboard for elbow confinement. The motion of the handgrips, through mechanical linkages and an initiator, fires the canopy remover which forcibly separates the canopy from the cockpit. Displacement of the canopy fires another initiator which in turn actuates the ballistic-rocket catapult, resulting in separation of the seat and pilot from the air vehicle. The rocket motor exhaust nozzle is canted at an angle of 34 degrees to direct the centerline of thrust through, or very close to, the center of gravity of the ejected mass. The burning rate of the two charges is designed to limit the magnitude and rate of onset of ejection forces to 20 g and 250 g per second, respectively.

Firing of the catapult by the canopy motion is dependent on prior raising of the ejection handles. This is required in order to retain provisions for emergency jettison of the canopy without ejecting the seat. Emergency jettison of the canopy is effected by a console-mounted control, or by an external ground rescue handle.

During seat displacement along the ejection guide rails, an interference tripper on the airframe engages a seat-attached bellcrank to arm the aneroid timer control for parachute deployment. Also actuated during this phase of ejection are the stabilizing devices which become effective simultaneously with seat-rail separation. During the final phase of guided travel, the rocket motor is ignited to add altitude and ensure clearance over the empennage under any flight condition.

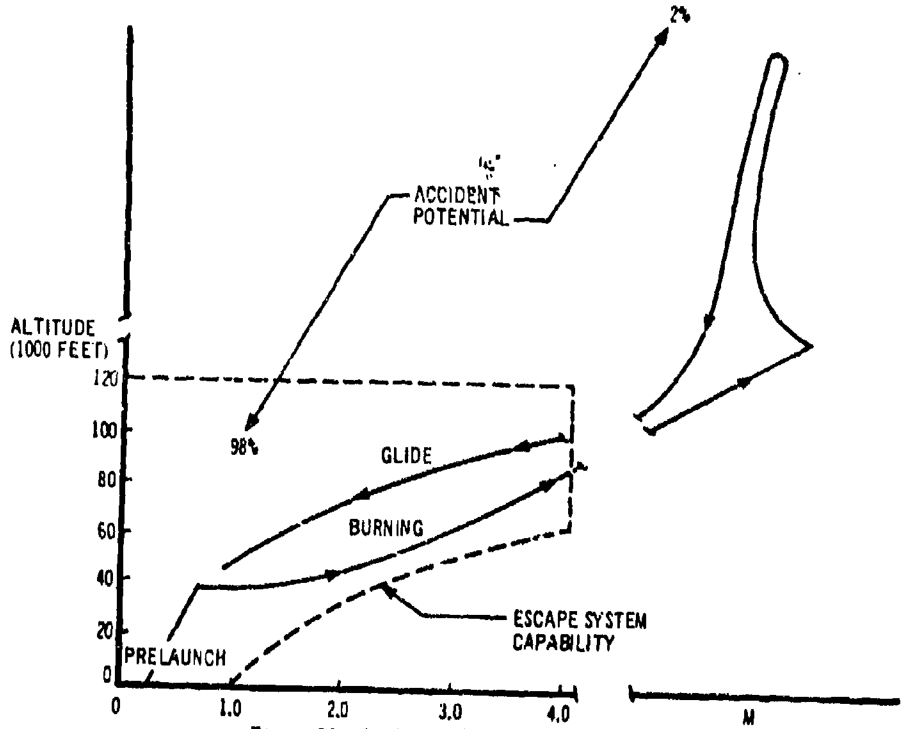


Figure 30. Analysis of X-15 Accident Potential

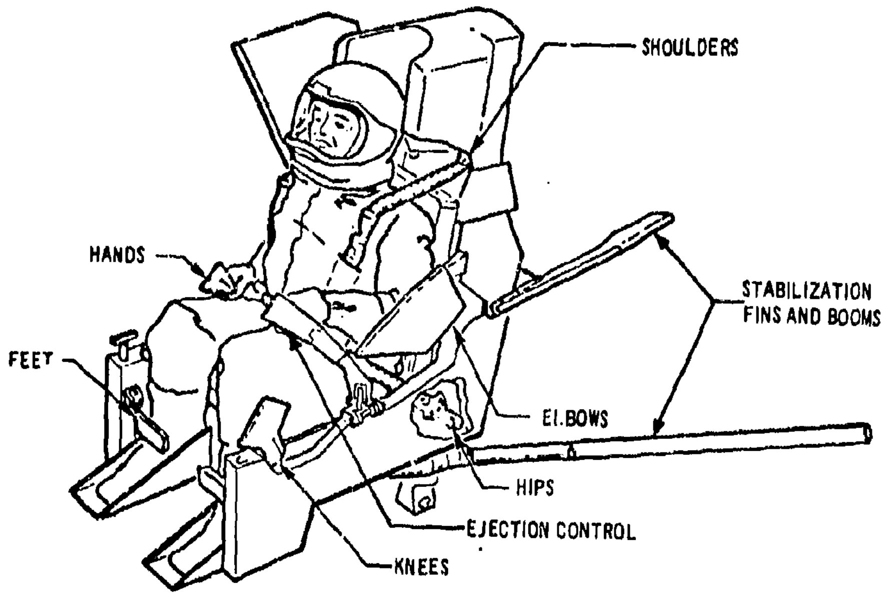
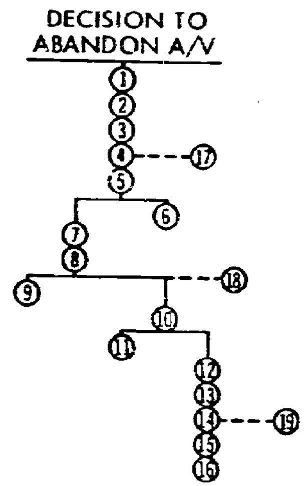


Figure 31. X-15 Ejection Seat Restraint System

PRIMARY

1. CONVERT TO EMERGENCY OXYGEN SUPPLY
2. PILOT POSITIONING (MANUAL)
3. RAISE EJECTION HANDLE
4. CANOPY REMOVER IGNITION AND CANOPY SEPARATION
5. BALLISTIC-ROCKET CATAPULT IGNITION AND SEAT EJECTION
6. ACTUATE STABILIZATION SYSTEM FINS AND BOOMS
7. ACTUATE ANEROID-TIMER CONTROL
8. FREE FALL TO 15,000 FEET AND/OR DELAY 3 SECONDS
9. LEG MANACLES AND EJECTION HANDLE RELEASE
10. HEADREST JETTISON
11. SHOULDER HARNESS RELEASE
12. PARACHUTE PACK OPENING AND PILOT CHUTE DEPLOYMENT
13. MAIN PARACHUTE DEPLOYMENT AND INFLATION
14. PILOT AND SEAT SEPARATION
15. AUTOMATIC CONVERSION TO EMERGENCY OXYGEN
16. PARACHUTE DESCENT AND GROUND CONTACT



ALTERNATIVES

17. INTERNAL AND EXTERNAL EMERGENCY CANOPY JETTISON HANDLE
18. EMERGENCY MANUAL RESTRAINT RELEASE AND HEADREST JETTISON
19. MANUAL SEAT AND PILOT SEPARATION AND MANUAL PARACHUTE RELEASE

Figure 32. X-15 Ejection Sequence Block Diagram

Following ejection, the pilot occupies the seat during free fall to 15,000 feet, if ejection occurs above that altitude, or for 3 seconds if below. The automatic control contains a bellows and powder-train time delay, with the bellows being dominant. The aneroid timer is responsible for release of the pilot restraint system and initiation of parachute deployment by jettisoning the headrest.

Two zero-speed, zero-altitude tests were accomplished to evaluate rocket catapult performance, the effect of rocket thrust misalignment, and to determine the system capability prior to sled testing. During both tests the trajectory zenith was 240 feet, and the rocket catapult performance was considered satisfactory, although zero-airspeed, zero-altitude capability was not indicated due to parachute/seat entanglement.

Seven sled ejection tests were conducted at Edwards Air Force Base. Successful parachute deployment was accomplished from ground level at speeds ranging from 180 to 690 knots. The lift characteristics of the seat are such that the recovery parachute was only partially inflated prior to ground contact on the 690 knot test. However, the tests demonstrated the effectiveness of the system to provide escape capability within the design criteria. Figure 33 shows the acceleration histories of the three-axis resultant obtained from ejection tests. Figure 34 is a seat and occupant trajectory for a 186-knot ejection.

g. NORTH AMERICAN HS-1 SEAT

The HS-1 seat was developed and manufactured by North American Aviation, Inc., Columbus, Ohio, for installation in the A-5 (A3J) airplane. This program commenced in 1956, covered the preliminary design, wind tunnel model testing, static firings, drop tests, rocket sled ejections, ejections from production aircraft, and component testing as presented in Ref. 3.

The HS-1 seat has an escape capability of up to 750 knots at sea level and up to Mach 2.2 at 35,000 to 70,000 feet altitude. The seat has a ground level capability down to approximately 70 knots. The seat performance envelope is shown in Fig. 35. The seat space envelope is shown in Fig. 36. A three quarter front view of an occupied seat is shown in Fig. 37.

Escape is initiated by actuation of the face curtain or either squeeze grip. The arms, legs, and torso are positioned and restrained. Both front and rear seat rocket catapults, Rocket Power, Inc. P/N 1289-4A, have a 0.40 second time delay to allow complete crew packaging and canopy removal prior to seat movement. When the crewman in the rear cockpit initiates ejection, the rear canopy is jettisoned, the man is packaged, and the seat is ejected. Initiation of the rear seat in no way affects the front seat or canopy. When the crewman in the front cockpit initiates ejection, both canopies are jettisoned simultaneously, both crewmen are packaged, the rear catapult is initiated, and 0.75 second later the front catapult is initiated. The rear crewman is always ejected prior to the front crewman. As the seat moves up the rails, the harness release system sequence is initiated and the 52-inch drogue chute is fired. Immediately after separation of the seat from the rails, the drogue

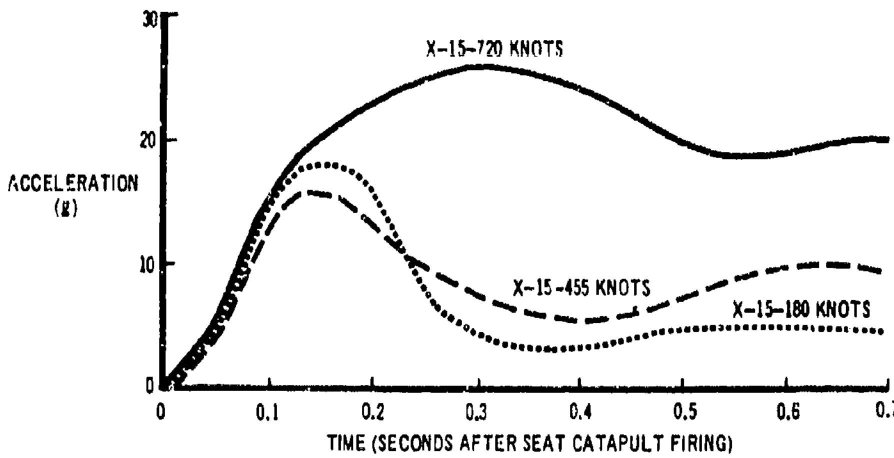


Figure 33. X-15 Seat Occupant Accelerations (CG 3-Resultant)

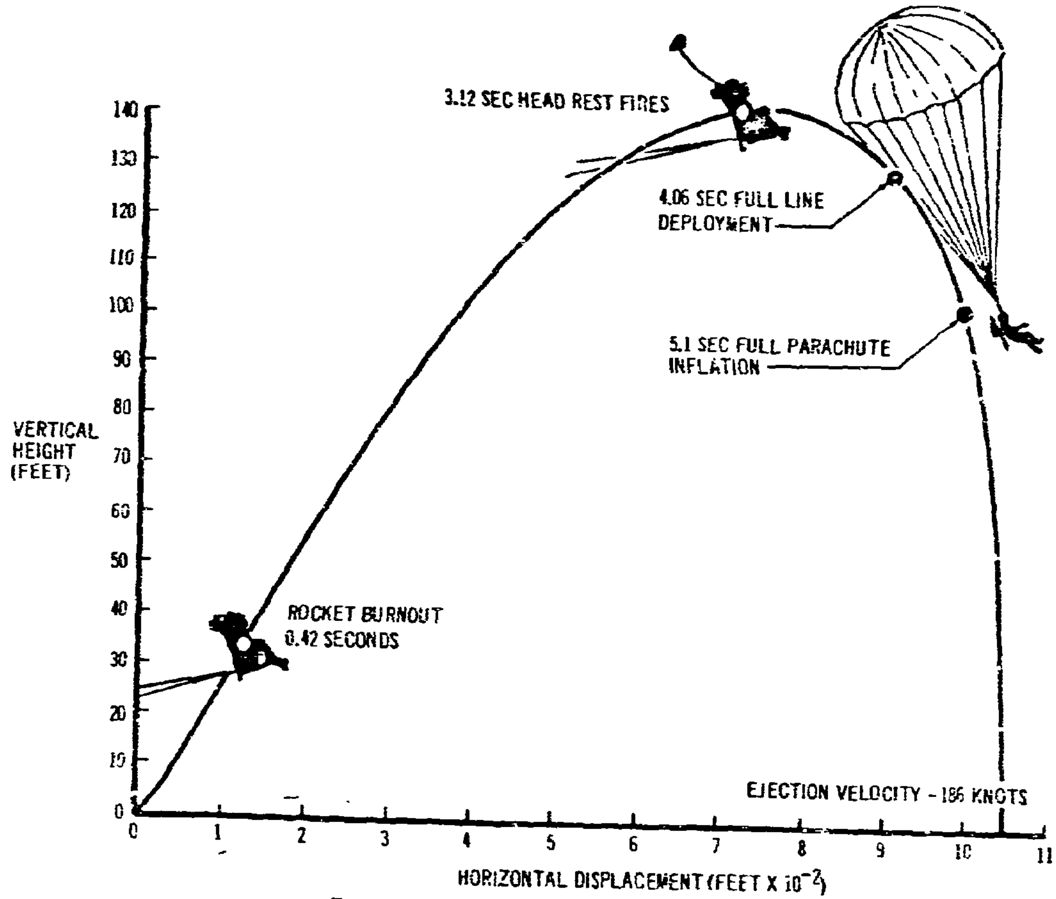


Figure 34. X-15 Seat and Occupant Trajectory

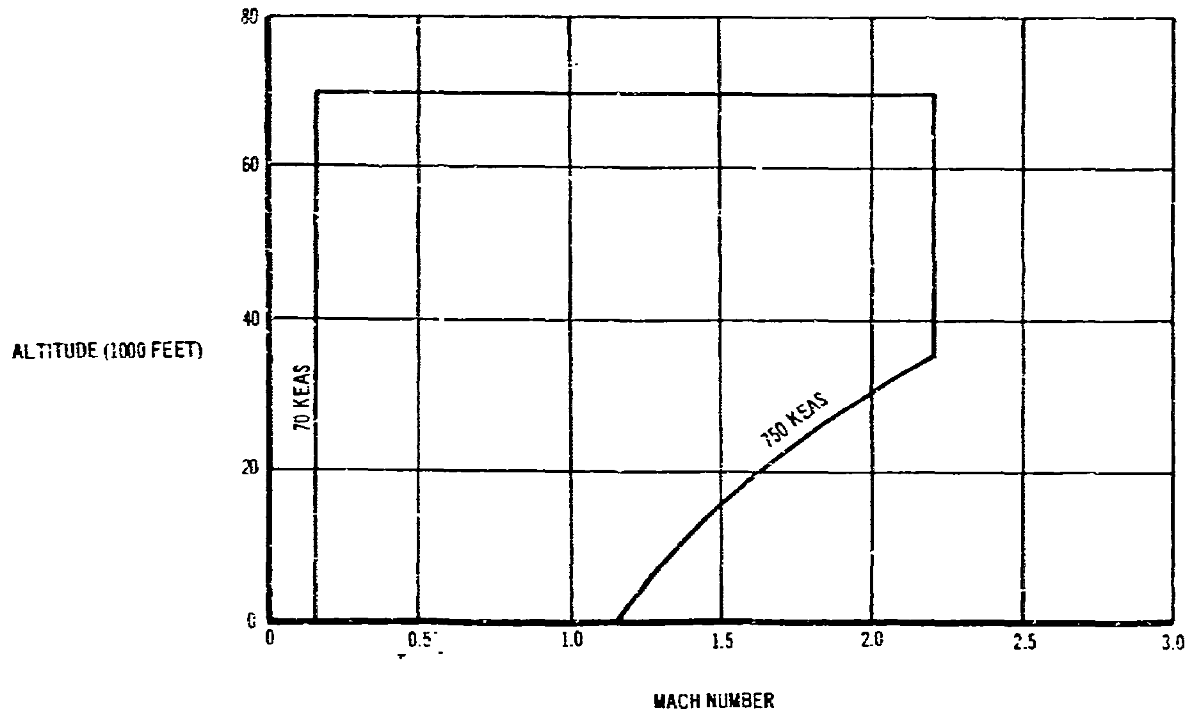


Figure 35. North American HS-1 Seat – Performance Envelope

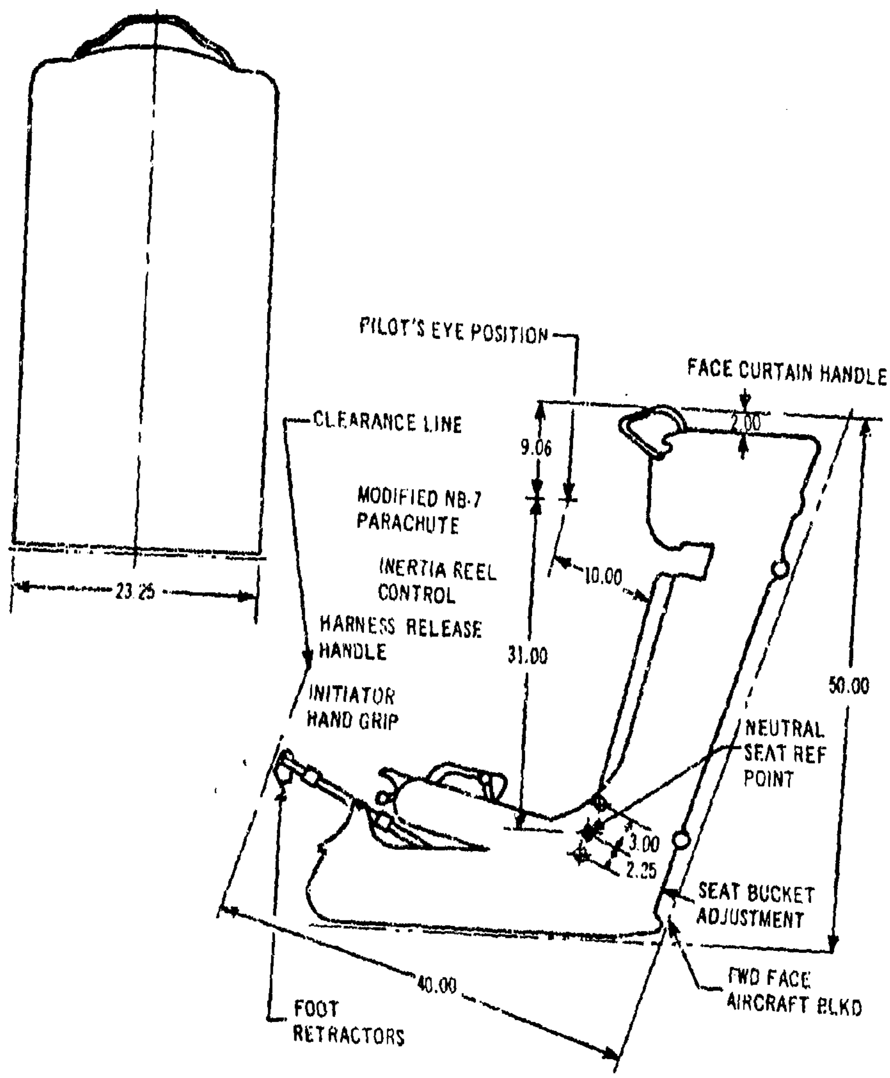


Figure 36. North American HS-1 Seat - Space Envelope

Figure 37. North American HS-1 Seat and Occupant

chute becomes fully inflated. The rocket further propels the seat upward. The torso harness is released from the seat and the two separation bladders are inflated. Simultaneous with this action, the leg restraint hooks are blown off and the knee bar and lower drogue chute risers are released. The arm retention system is released by upward movement of the survival kit as the bladders inflate. After the lower drogue risers are released from the lower part of the seat, the seat rotates head-aft until the upper risers become free of the top hooks. As the drogue separates from the seat, a lanyard from the upper left drogue riser attached to the parachute static line provides deployment of the 28-foot diameter NB-7E personnel parachute. A ballistic cutter severs the static line after personnel parachute deployment to separate the drogue. A schematic of the front crewman's escape system is shown in Fig. 38. The rear crewman's system is similar except as noted. Timing of the escape sequences is shown in Table V.

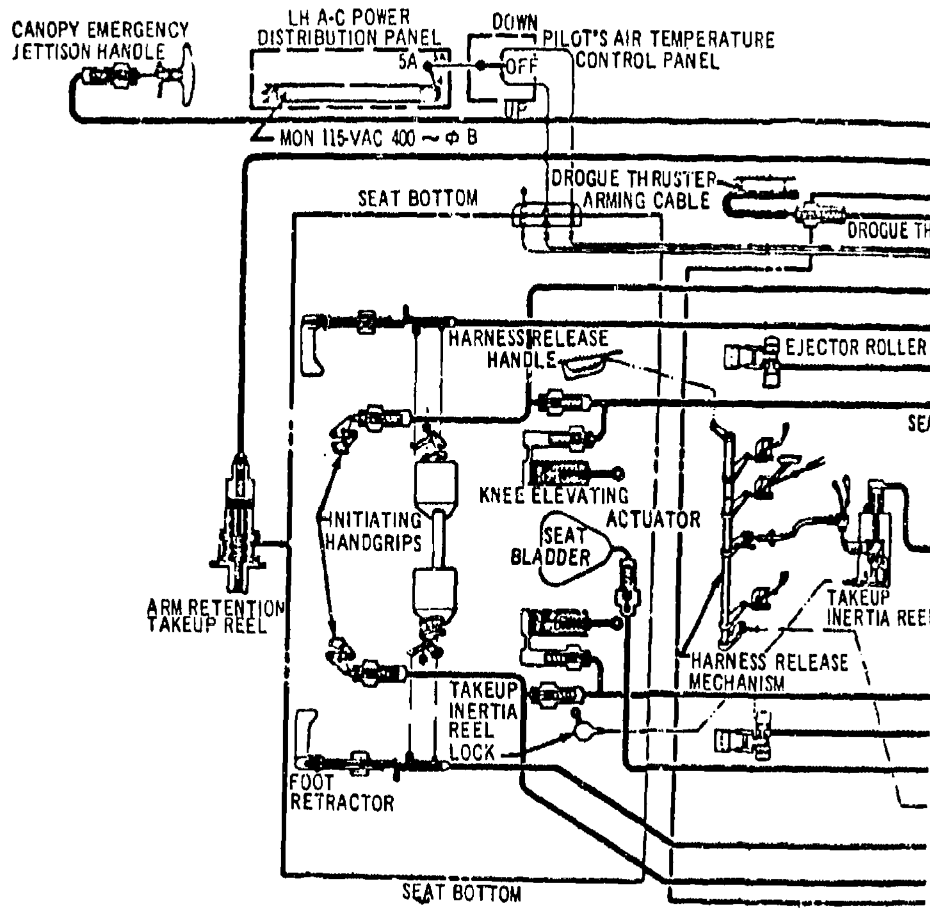
Table V. North American HS-1 Seat – Escape Sequence Timing

Time (Sec)	Action
0.0	Front crewman initiates.*
	Front and rear canopies jettisoned.
	Torso and extremities positioned and restrained and seats bottomed (front and rear crewmen).
0.2	Both crewmen completely packaged
0.3	Front canopy clears aft cockpit at 101 knots
0.4	Rear seat catapult fired
0.5	Rear seat separation manifold initiated
0.52	Rear seat drogue chute ballistically deployed
0.57	Rear seat clears aircraft
0.58	Rear seat drogue chute reaches full line stretch following ejection at 750 KEAS
1.15	Front seat catapult fired
1.25	Front seat separation manifold initiated
1.27	Front seat drogue chute ballistically deployed
1.32	Front seat clears aircraft
1.33	Front seat drogue chute reaches full line stretch following ejection at 750 KEAS
2.26	Rear seat seat-man separation
3.01	Front seat seat-man separation

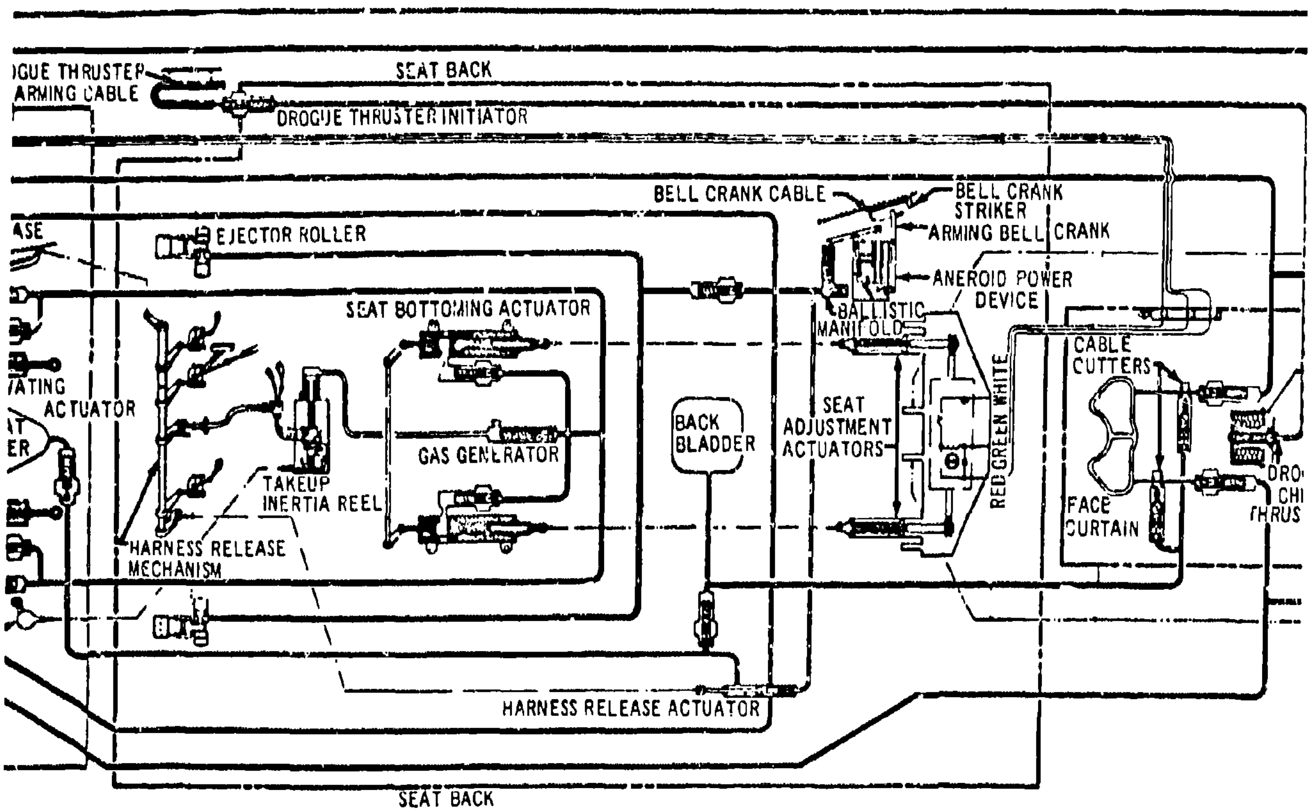
* The rear crewman can eject by himself at any time. Timing would be exactly as shown above for the rear seat. The front canopy would not be jettisoned.

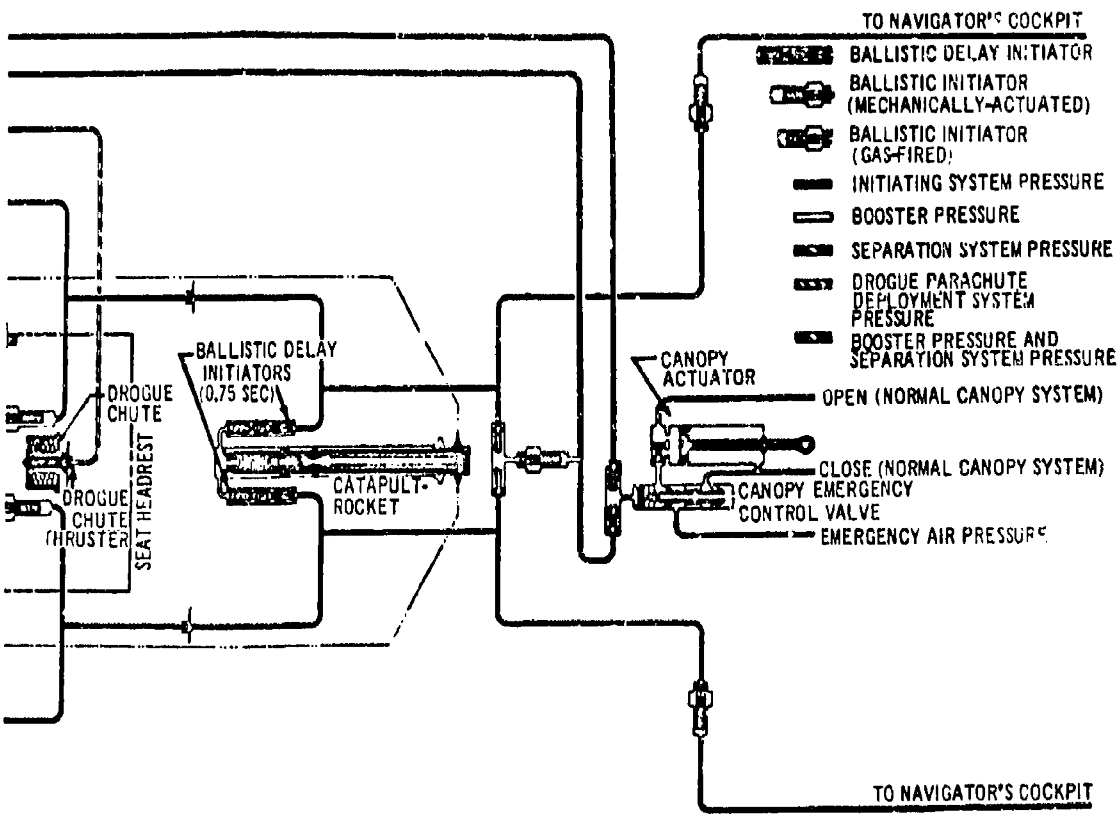
A backup system for personnel parachute deployment is provided. As the man separates from the seat, a static line fires an 0.75 second delay in the automatic opener in the personnel parachute pack. Should the drogue chute be inoperative or fail to release from the seat, the automatic opener will deploy the personnel parachute after the time delay.

When ejection occurs below 13,000 feet, drogue release, harness release, and seat-man separation occur 1.76 seconds after the separation


CANOPY EMERGENCY
JETTISON HANDLE
LH A-C POWER
DISTRIBUTION PANEL
5A
DOWN
OFF
UP
PILOT'S AIR TEMPERATURE
CONTROL PANEL
MON 115-VAC 400 ~ Φ B
DROGUE THRUSTER
ARMING CABLE
SEAT BOTTOM
DROGUE THR
HARNESS RELEASE
HANDLE
EJECTOR ROLLER
SEA
KNEE ELEVATING
ACTUATOR
INITIATING
HANDGRIPS
SEAT
BLADDER
ARM RETENTION
TAKEUP REEL
TAKEUP
INERTIA REEL
HARNESS RELEASE
MECHANISM
TAKEUP
INERTIA
REEL
LOCK
FOOT
RETRACTOR
SEAT BOTTOM

T'S AIR TEMPERATURE
CONTROL PANEL





C

Figure 38. North American HS-1 – Pilot Escape System Schematic

manifold is initiated through a 1.46 second ballistic delay plus inherent time delays. When ejection occurs above 13,000 feet, initiation of the ballistic delay is blocked out until seat-man descend to this altitude. Should the primary personnel chute deployment system malfunction above 10,000 feet, the secondary system performs, except that the automatic opener will not open the parachute pack until 0.75 second after reaching 10,000 feet.

Manual overrides to the retention and separation systems are provided. The personnel parachute provides a ripcord for manual operation, and provisions are made for manually releasing the arms and legs following automatic positioning and restraint.

Should the normal pneumatic canopy jettison system malfunction, the canopy is removed by the seat moving up the rails.

The survival kit is located in the seat bucket and serves as a support for the seated crewman. It contains a standard PK-2 kit, a 70 cubic inch oxygen bottle, and the pressure suit regulator.

Table VI gives the escape system weight breakdown.

Table VI. North American HS-1 Escape System Weight Breakdown

Seat assembly (includes drogue chute, harness thruster, drogue thruster, inertia reel, adjustment mechanism, seat structure, inner portion of catapult rocket, lift plate, miscellaneous ballistic hardware).		220 lb
Useful Load		60
NB-7E parachute	25 lb	
Survival container with equipment	35 lb	
Nonejectable Items (Includes outer portion of rocket catapult, arm retention reel, ballistic devices on seat bulkhead and miscellaneous hardware)		23
Note: Ejection rail weight not included. Weight of ejection rail will depend upon mounting bulkhead rigidity. On A-5 airplane rails weigh approximately 50 lbs. If bulkhead had increased rigidity with resulting less deflection this weight could be reduced.		
Total Installed Weight (Less Seat Rails)		303 lb

A 5 percentile man will experience a peak transverse acceleration of about 53.5 g with a mean rate of onset of about 218 g/sec. and a maximum rate of onset of about 562 g/sec. following an ejection from an A-5 airplane at 750 KEAS at sea level. Similar figures for a 95 percentile man are 47.0 g at rates of onset of 192 g/sec. and 495 g/sec., respectively. Typical acceleration-time histories are shown in Figs. 39, 40, and 41 for 5 and 95 percentile crewmen at low, intermediate, and high speeds. Trajectories at low, intermediate, and high speeds are shown in Fig. 42.

h. NORTH AMERICAN LS-1 SEAT

The LS-1 ejection seat was developed and manufactured by North American Aviation, Inc., Columbus, Ohio, for installation in the T-2A (T2J-1) airplane. This program commenced in 1956 and covered design, analysis, and testing. The system is U. S. Navy qualified and has been operational in the T2J-1 since January 1958. It has undergone 40 dynamic tests from rocket sleds and aircraft at velocities from 50 to 600 KEAS and at altitudes from ground level to 43,000 feet. The LS-1 escape system will recover a crewman ejecting "on the deck" at all airspeeds from 50 to 525 knots indicated and at all speeds less than 525 knots indicated at altitudes, with a Mach limitation of between 2.5 and 3.0. The performance envelope is shown in Fig. 43. An additional capability of zero altitude-zero speed recovery was obtained by incorporating two seat modifications. The rocket impulse was increased from 940 lb sec to 1,060 lb sec, and the hesitator loops for the personnel parachute shroud lines were changed to the configuration previously developed and qualified on the LW-2 escape system. A zero-zero static firing was successfully demonstrated on a modified LS-1 seat system with a 95 percentile anthropometric dummy. A minor structural change to the seat and drogue chute risers extends seat structural integrity from the demonstrated 525 KEAS to 600 KEAS. The seat space envelope is shown in Fig. 44. The general arrangement is shown in Fig. 45. The integrated harness release system is shown in Fig. 46.

Figure 47 shows a schematic of the LS-1 seat system used on the T-2A airplane prior to the incorporation of a command ejection system. In the system shown in Fig. 47, the forward seat ejects through the canopy if the canopy has not been jettisoned by the aft seat occupant, or by the forward or aft cockpit canopy jettison handle. Later models of the T-2A airplane are equipped with a command selector system which prevents the forward seat from ejecting until after the aft seat has ejected. The entire escape sequence is initiated by pulling either the face curtain or D-ring. Actuation of either fires two mechanical initiators which in turn generate pressure to fire the inertia reel initiator, canopy remover initiators, and the rocket-catapult. The rocket-catapult incorporates an 0.4 second delay to allow positioning of the crewman and removal of the canopy. As the seat moves up the rails, a drogue gun is fired to deploy the stabilization drogue chute. At the same time the aneroid fires the 0.5 second harness release time delay. If below 13,000 feet, the aneroid fires the 0.5 second harness release time delay. If above 13,000 feet, the stabilized seatman will descend to 13,000 feet before the harness release time delay is fired. After this time delay, a thruster is fired to release the two lap belt and shoulder harness attachment points. Gas from this thruster also fires two initiators which provide pressure to fire the face curtain cable cutters and inflate the seat-man separation bladders. A static line fires the 0.75 second

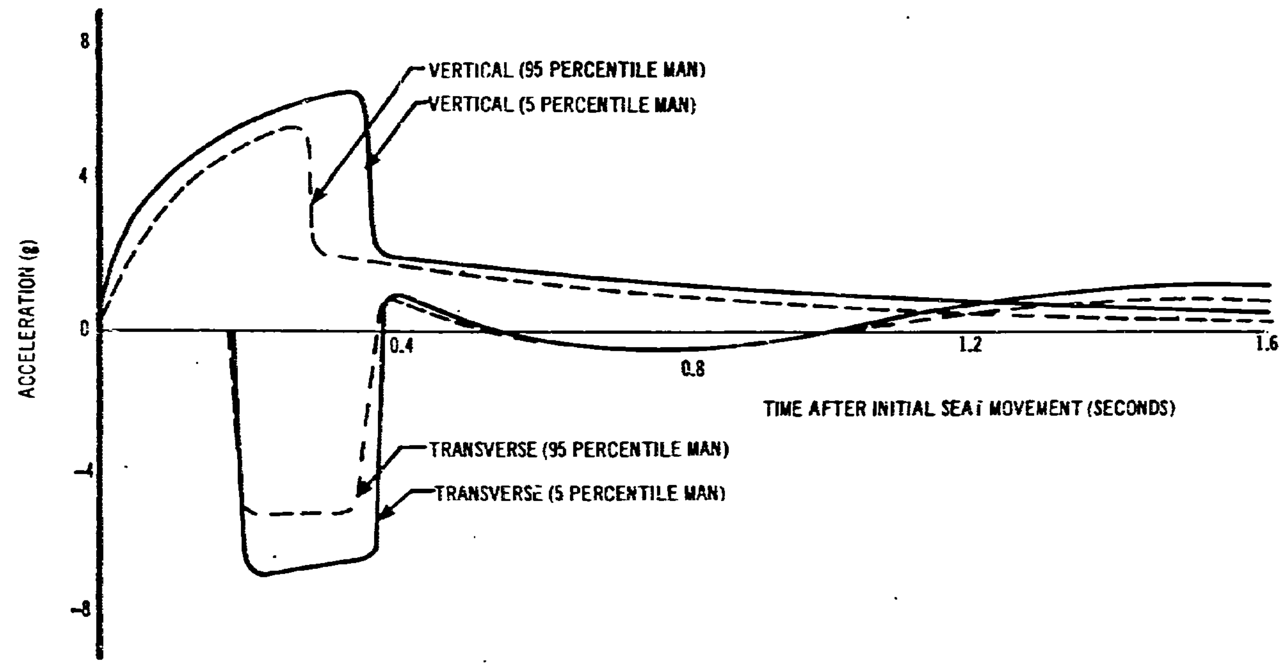


Figure 39. North American HS-1 Seat Escape System – G-Time History–Sea Level–100 Knots

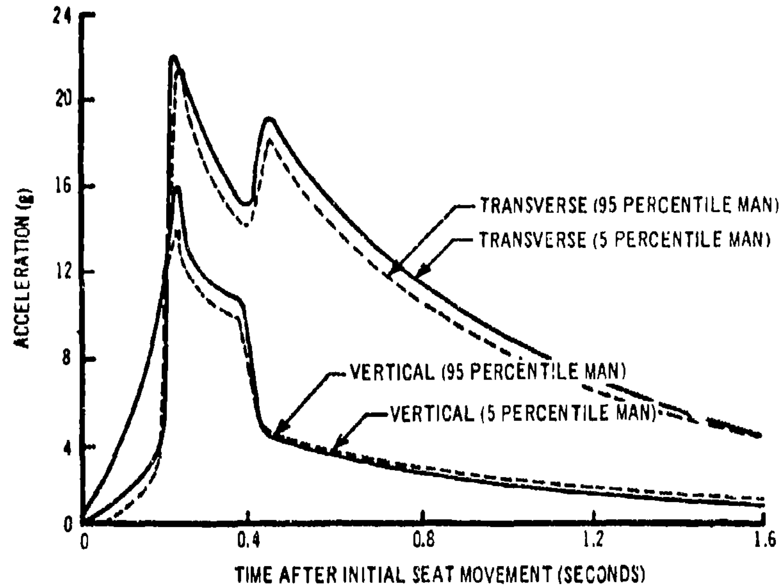


Figure 40. North American HS-1 Seat Escape System – G-Time History–Sea Level–500 Knots

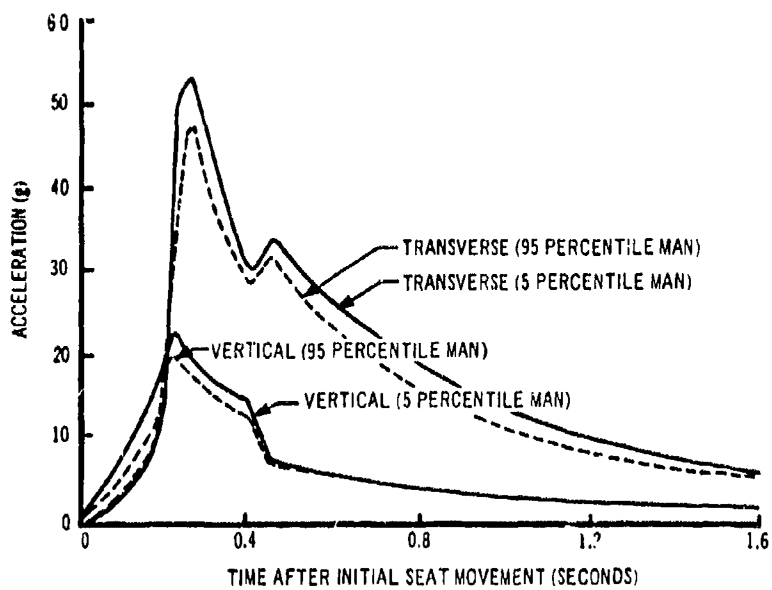


Figure 41. North American HS-1 Seat Escape System – G-Time History–Sea Level–750 Knots

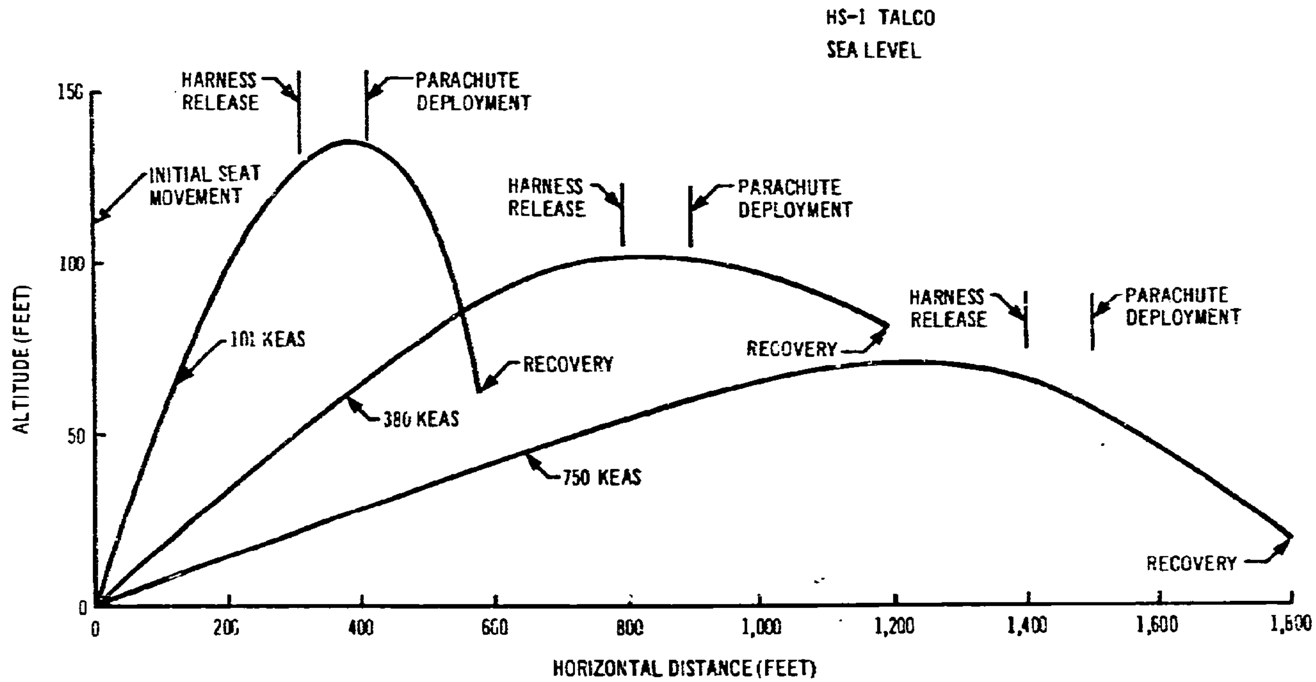
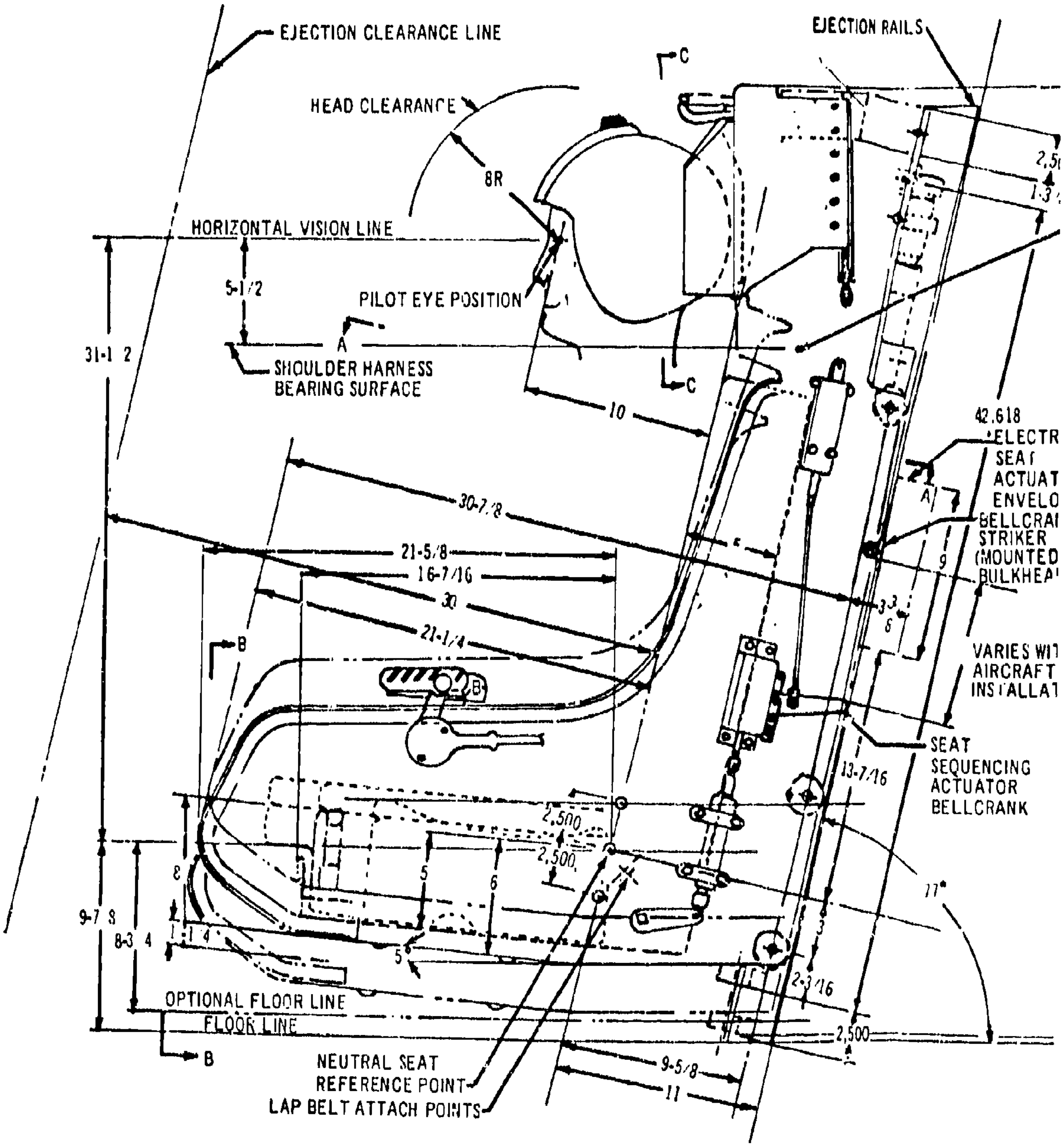


Figure 42. North American HS-1 Seat Dummy Trajectories


EJECTION CLEARANCE LINE
EJECTION RAILS
C
HEAD CLEARANCE
8R
HORIZONTAL VISION LINE
5-1/2
PILOT EYE POSITION
A
SHOULDER HARNESS
BEARING SURFACE
31-1 2
C
10
42.618
30-7/8
21-5/8
16-7/16
30
21-1/4
B
B
9
VARIES WI
AIRCRAFT
INSTALLA
SEAT
SEQUENCING
ACTUATOR
BELLCRANK
13-7/16
2,500
2,500
5
6
8
9-7 8
8-3 4
1 4
5
77°
3
2-3/16
OPTIONAL FLOOR LINE
FLOOR LINE
2,500
B
9-5/8
11
NEUTRAL SEAT
REFERENCE POINT
LAP BELT ATTACH POINTS

delay in the automatic parachute opener at the time of seat-man separation. The opener then deploys the NB-7 personnel parachute after the time delay.

The survival kit container is located in the seat bucket. It contains the required survival equipment, the PK-2 pararaft, and the emergency oxygen system.

A time history of escape accelerations for a 485 KEAS ejection is given in Fig. 48.

Trajectories at low, intermediate, and high speeds for the 5 percentile man and the 95 percentile man are shown in Fig. 49. Table VII gives the seat escape system weight breakdown.

1. NORTH AMERICAN LW-1 AND LW-1A SEATS

The North American LW-1 seat is a rocket-catapult, open-type, upward ejection seat designed in 1960 to meet the emergency escape needs of VTOL-STOL and flying platform type U. S. Army vehicles. It was produced in limited quantities for U. S. Army test vehicles. The LW-1 has a zero-altitude, zero-airspeed capability and a maximum speed capability of approximately 300 KEAS, and was not designed for ejections above 10,000 feet altitude. The LW-1A seat is basically an LW-1 seat strengthened to increase the maximum speed capability to 400 KEAS and modified to incorporate features such as ballistic inertia reel, oxygen bottle, vertical adjustment, aneroid device for parachute deployment, and speed sensor. The LW-1A seat was not procured because the LW-2 seat fulfilled the same operational requirements.

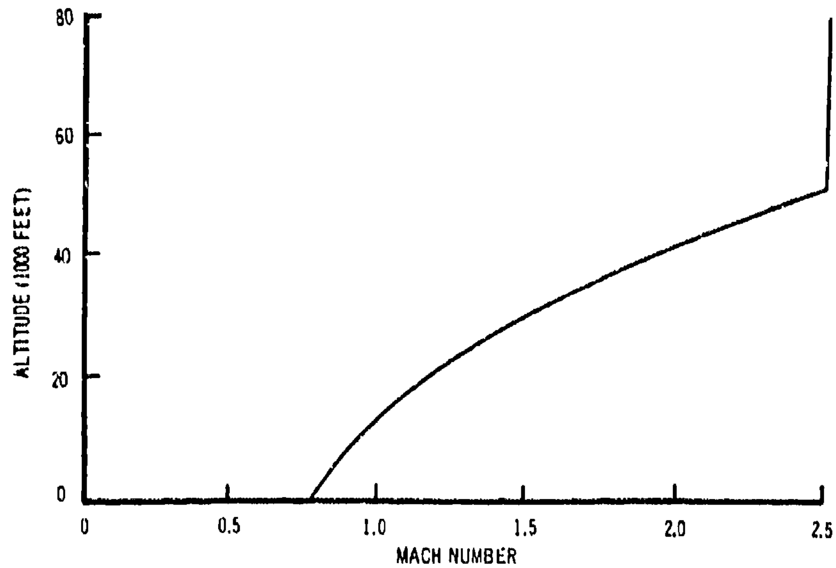


Figure 43. North American LS-1 Seat – Performance Envelope

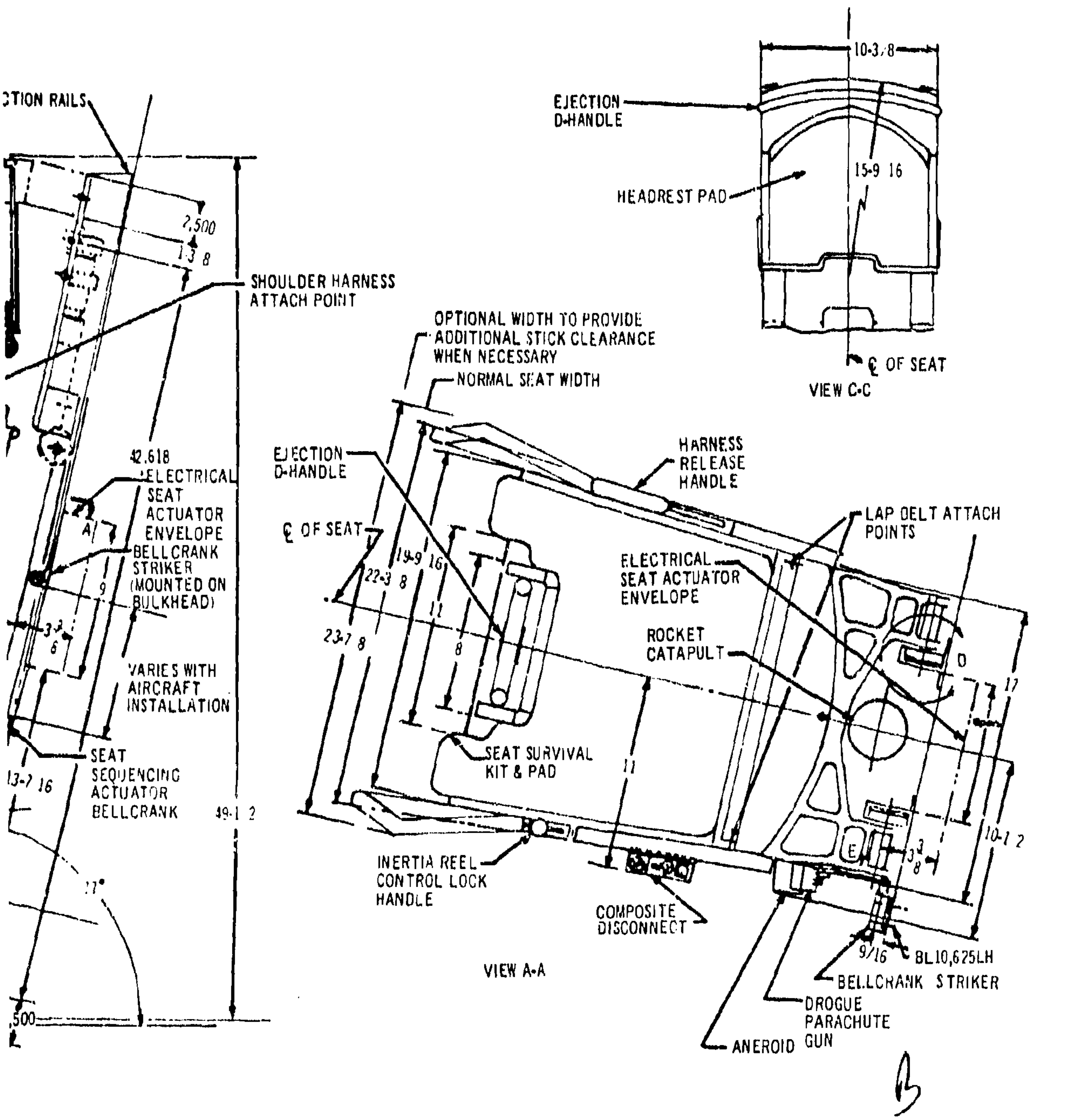


Figure 44. North American LS-1 Seat – Space Envelope

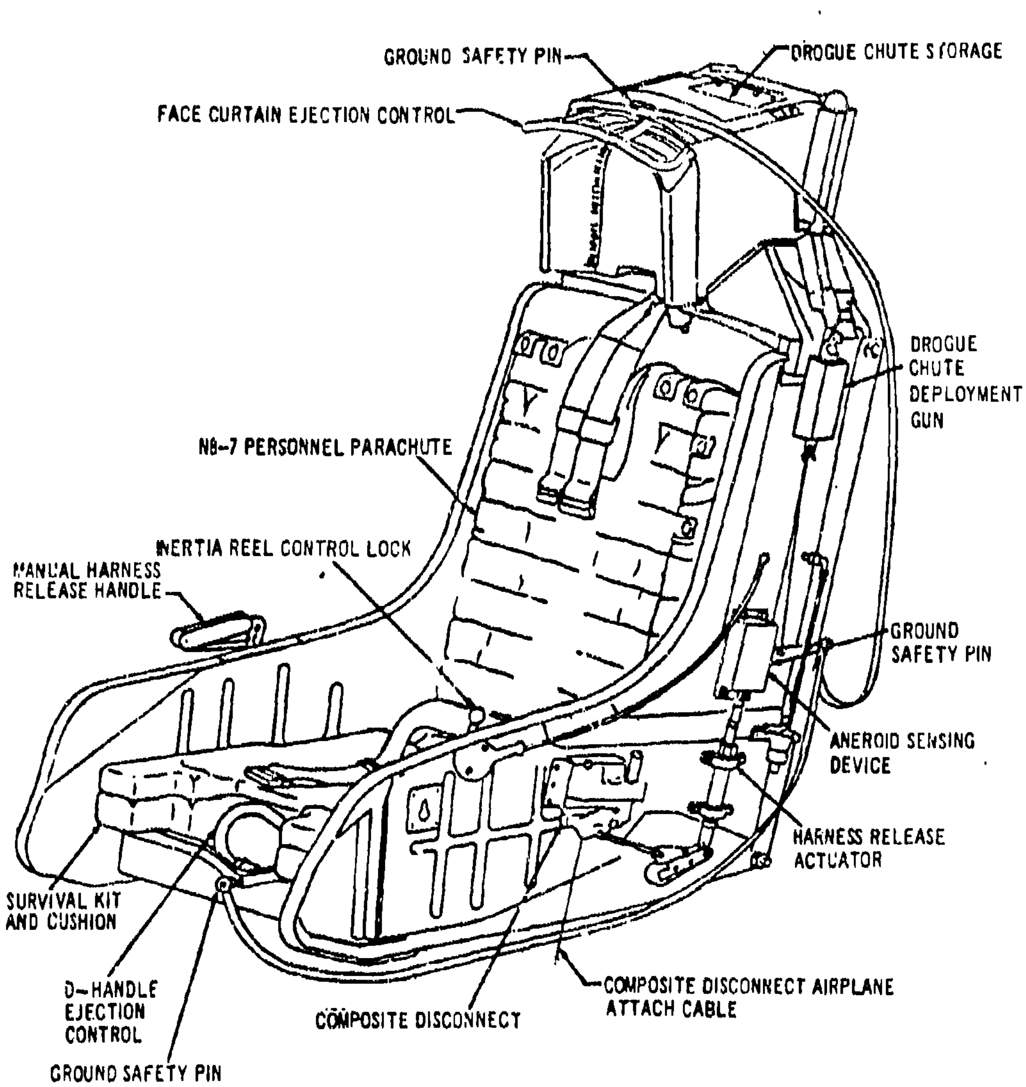


Figure 45. North American LS-1 Seat – General Arrangement

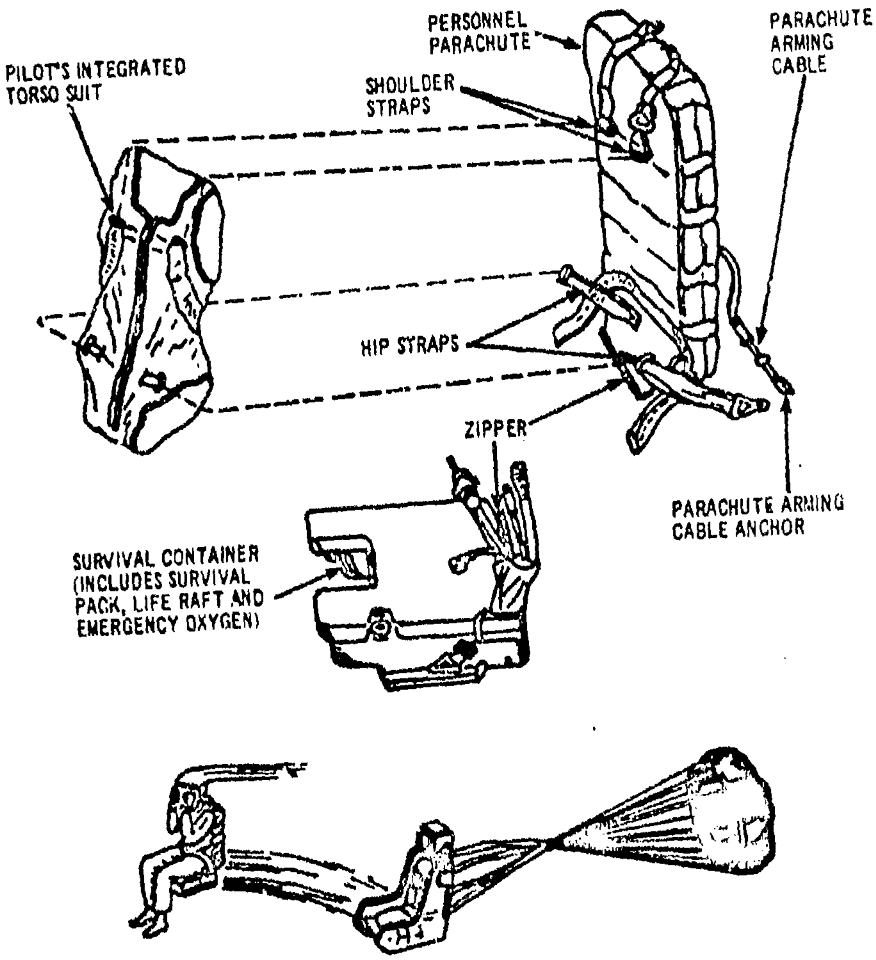


Figure 46. North American LS-1 Seat – Integrated Harness Release System

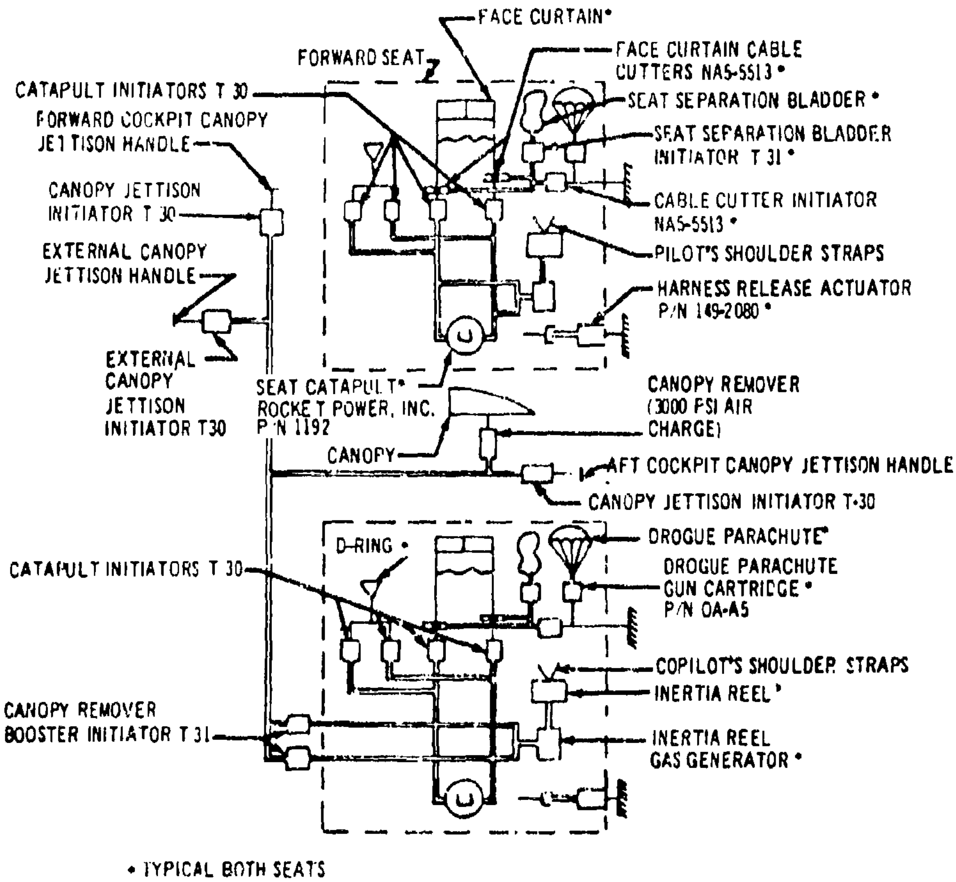


Figure 47. North American LS-1 Seat – Schematic of Escape System

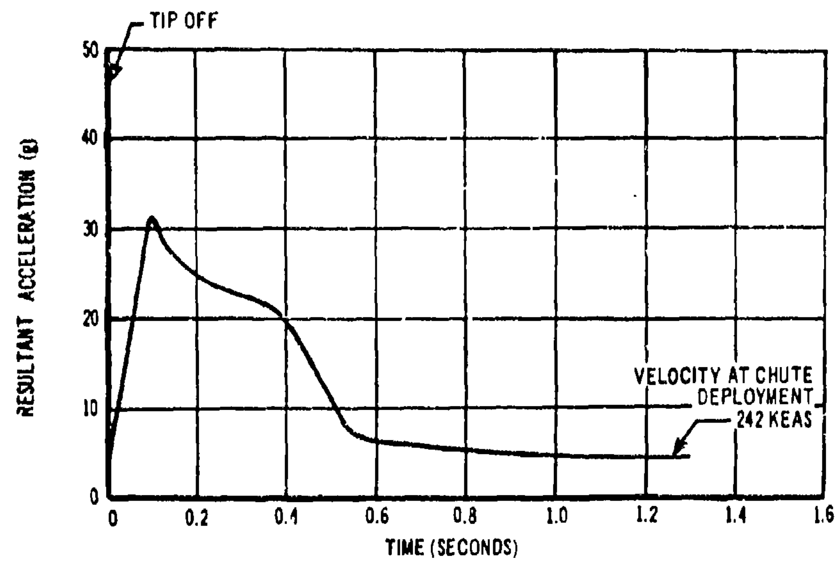


Figure 48. North American LS-1 Seat – Acceleration Time History – 485 KEAS

The LW-1 escape system consists of a structural chassis incorporating guide rails: and an ejection seat incorporating an integrated harness, D-ring ejection handle, parallel ballistic system, rocket-catapult, seat separation system, parachute system, AN/PRC-49 transceiver, canopy breaker, emergency release handle, and space for survival equipment. Figure 50 shows an early model LW-1 seat without some of these features. The rocket-catapult is a modified type XM9 with XM10 nozzle.

The seat separation system was designed so that the seat bottom and rails separate from the seat back, which is secured to the man's back throughout the descent. Figure 51 shows the seat after separation. To accomplish the separation, the seat back is secured to the rails by a toggle-type disconnect and tongue and groove joint located at the headrest, and by a breakaway fitting located at the hip line. The parachute system consists of a ballistic drogue gun, a 36-inch diameter P-A7 pilot chute, and a 28-foot diameter flat canopy main recovery chute located in a long, cylindrical bag fastened vertically to the left side of the seat back. The canopy breaker is a wedge-shaped flat plate on top of the headrest. The emergency release handle for releasing the man and attached seat back from the seat is located on the right-hand side of the headrest. An inertia reel is not on the seat, but may be incorporated. The seat was designed to withstand crash loads of 20 g forward, 12 g down and aft, 5 g upward, and ejection loads of 20 g upward. Figure 52 shows the seat envelope, and the ejection sequence is shown in Fig. 53.

Table VII. North American LS-1 Seat Escape System Weight Breakdown

Item		Weight (Lb) 5 Percentile	Weight (Lb) 95 Percentile
Ejected portion of seat		103	103
Nonejected seat provisions		38	38
Elect seat adjust	16		
Lower half rocket-catapult	10		
Tracks and supports	12		
Total Seat Components		141	141
Survival equipment		47	47
Contents	12.[illegible]		
Container with bail-out oxygen	10.4		
NB-7 parachute	24.0		
Man		133	201
Flying apparel		20	20
Total Seat Installation		341	409
Total Ejectable Weight		303	371

Ejection is accomplished by pulling on the D-ring handle, which fires two T30E1 initiators plumbed in parallel (for added reliability). Firing either initiator ignites the rocket catapult, which propels the seat up the fixed rails and continues thrust force for a short duration during seat-man free flight. As the seat travels up the fixed rails a lanyard actuates the transceiver location aid, and a mechanical trip device fires the drogue gun. The projectile from the gun is attached to the pilot chute, causing the pilot chute to be deployed. Projectile momentum and pilot chute drag force immediately deploys the main recovery chute. As the main recovery chute is deployed, a lanyard attached to a riser trips an over-center latch on the seat, and the seat bottom and rails fall free from the seat back. This leaves the survival kit and seat-back strapped to the man throughout his descent.

The rapid deployment of the main chute is advantageous for zero-speed zero-altitude, sink rate (Fig. 54), and angle of dive capabilities (Fig. 55), although it compromises high speed ejections. The structural limitations of the main chute and deceleration loads imposed on the man preclude ejections greater than approximately 300 KEAS. The predicted trajectories are shown in Fig. 56, and the LW-1 seat design performance envelope is shown in Fig. 57. Since the seat does not incorporate an oxygen bottle or aneroid device for parachute deployment, it is not suitable for high-altitude ejections.

The LW-1A seat is basically a strengthened LW-1 seat designed to add a seat vertical adjustment actuator, ballistic inertia reel, speed sensor, aneroid device for parachute deployment, and oxygen bottle. All of these items are included in the LW-1A weight breakdown (Table VIII.) Strengthening the

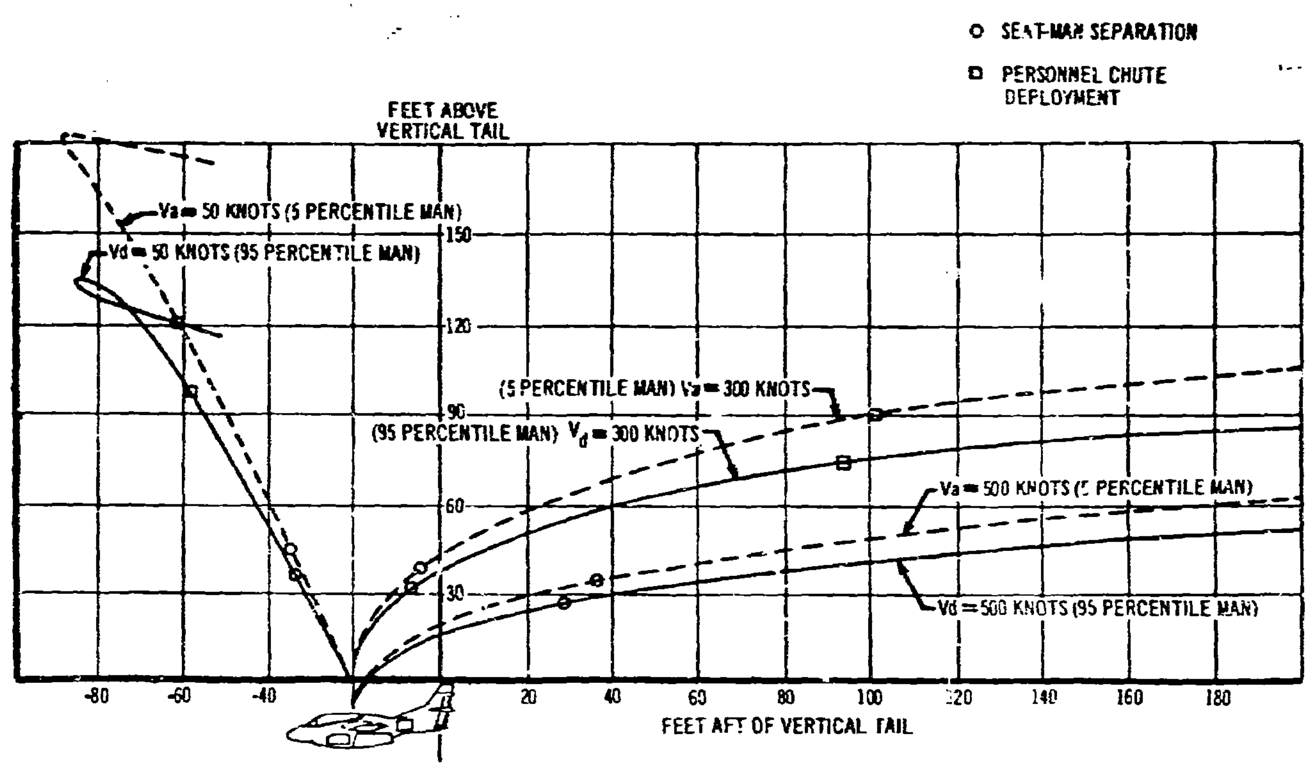


Figure 49. North American LS-1 Seat – Seat/Man Trajectories

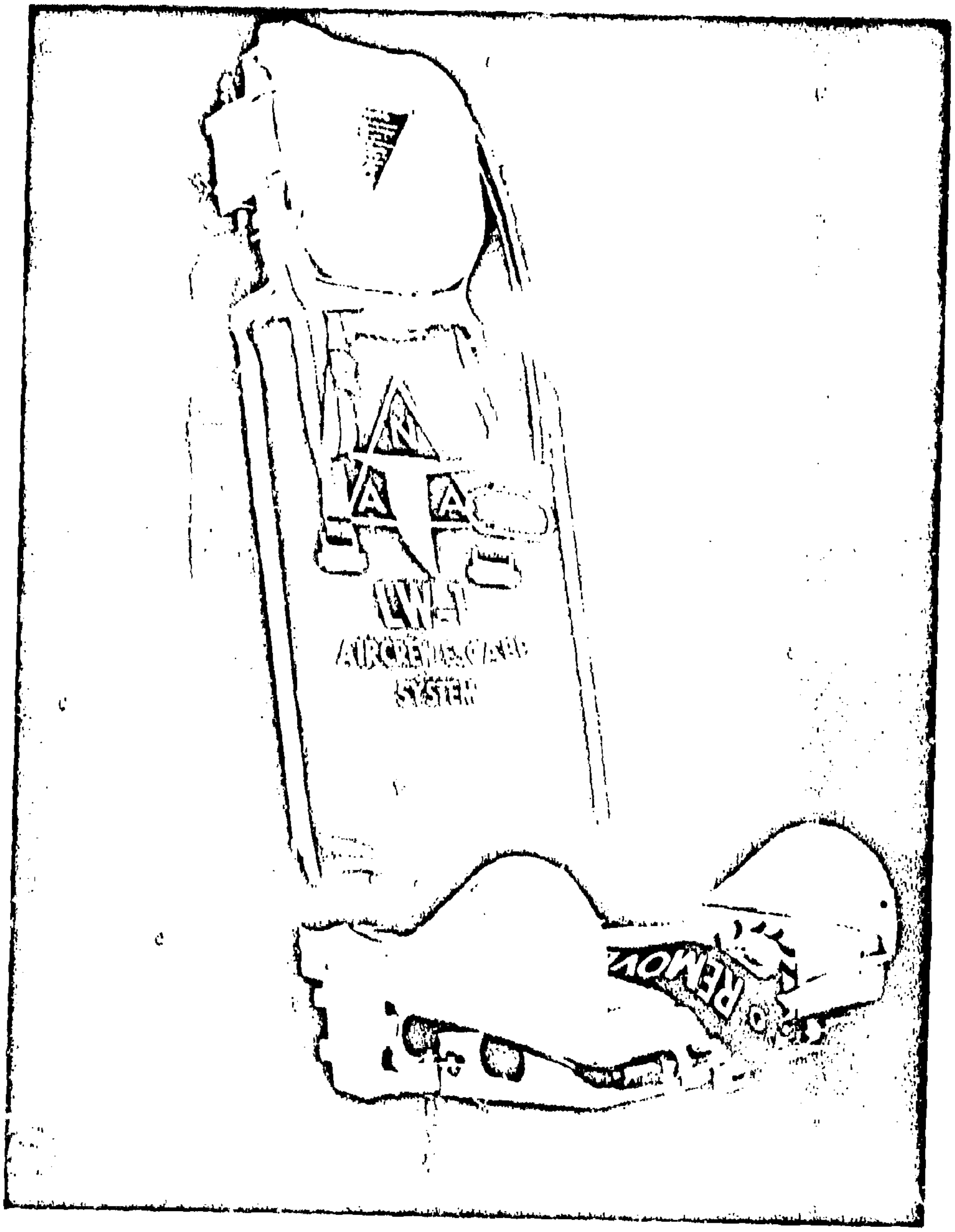


Figure 50. North American LW-1 Seat

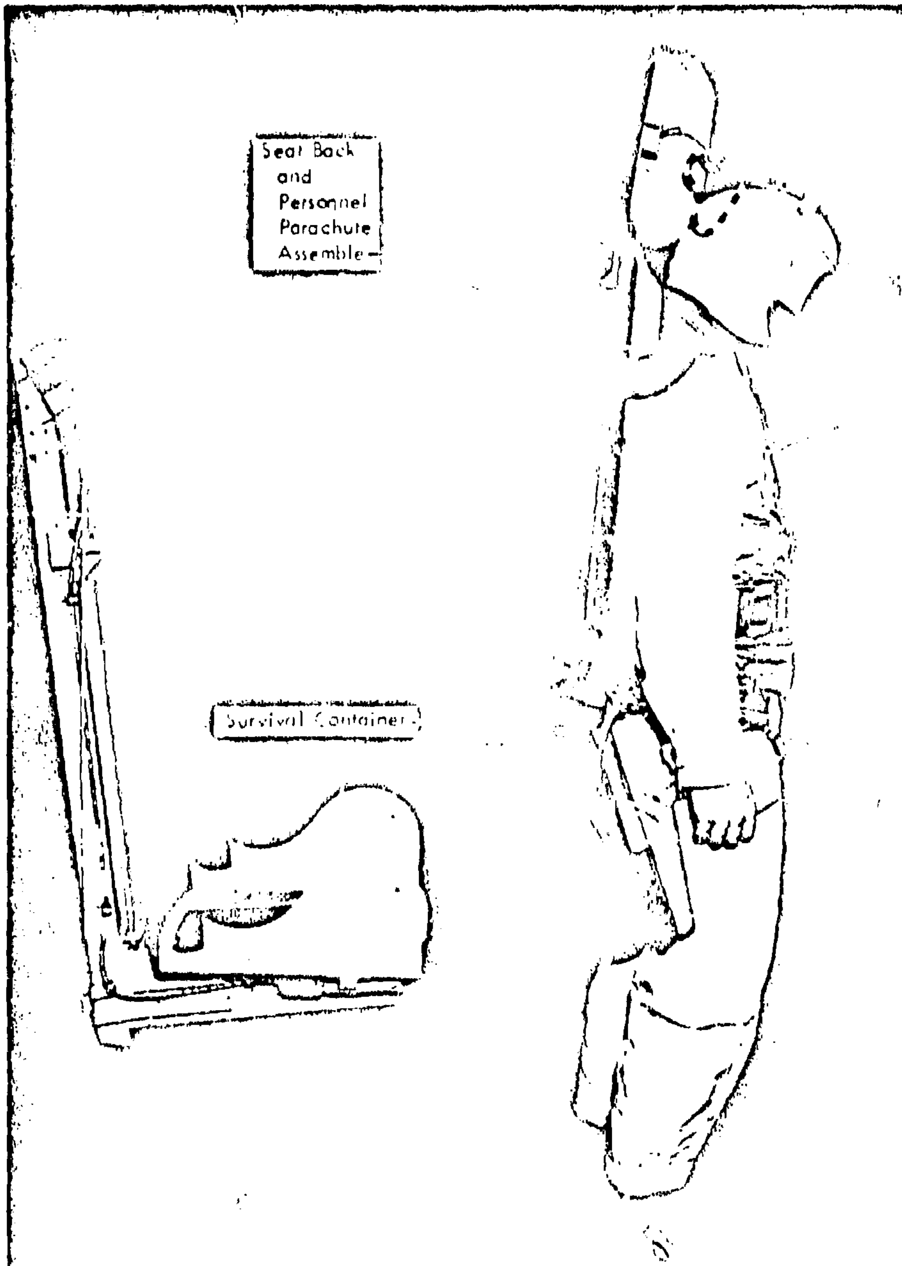


Figure 51. North American LW-1 Seat after Separation

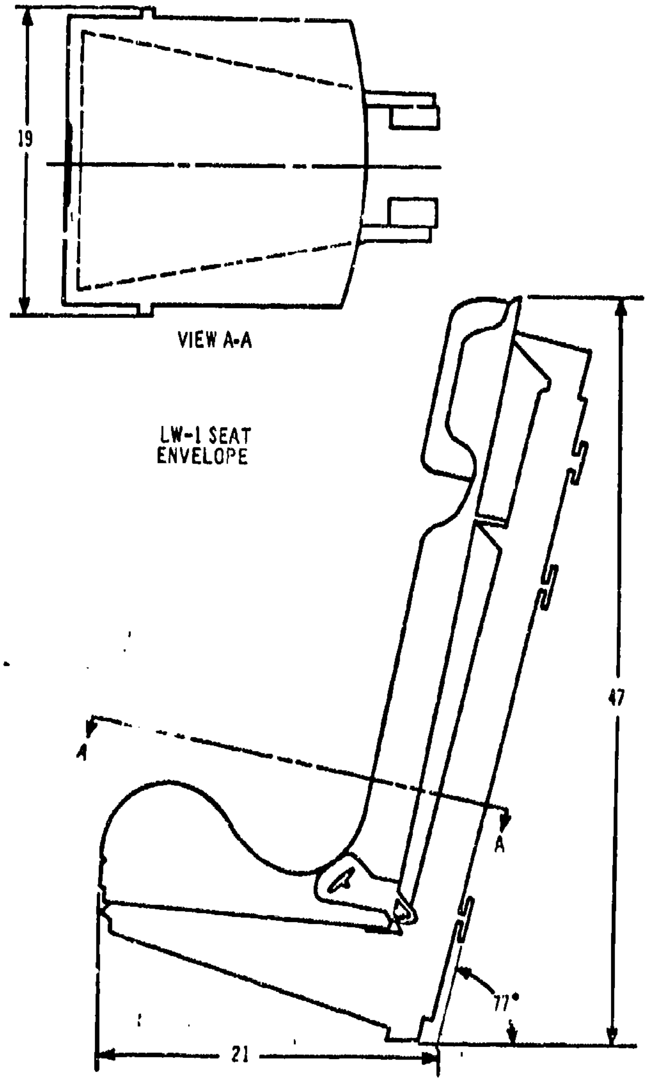


Figure 52. North American LW-1 Seat Envelope

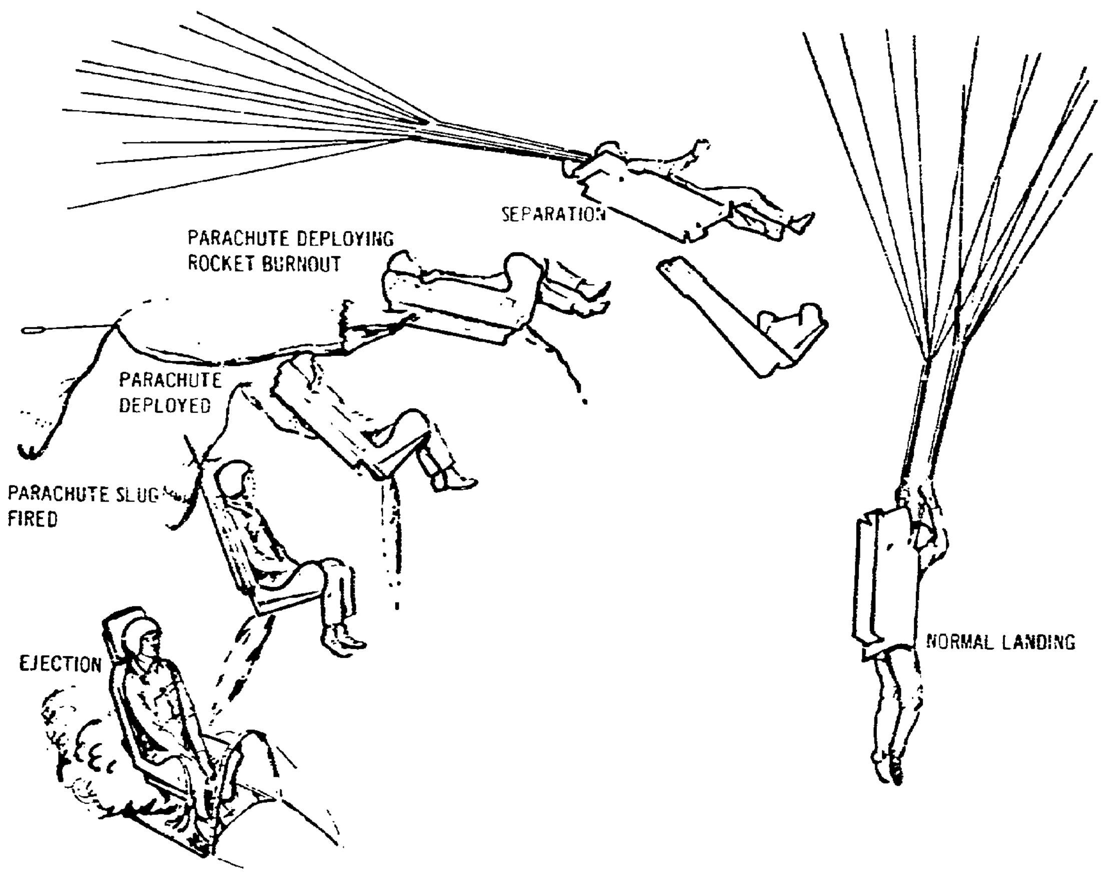


Figure 53. North American LW-1 Seat Ejection Sequence

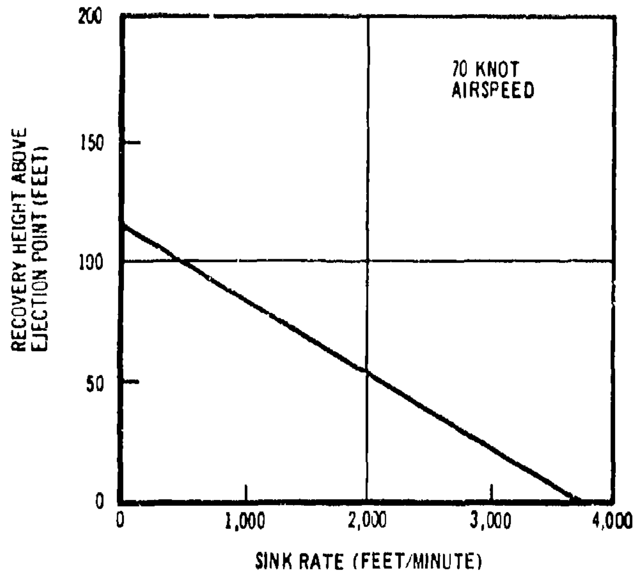


Figure 54. LW-1 Sink Rate Recovery Capability

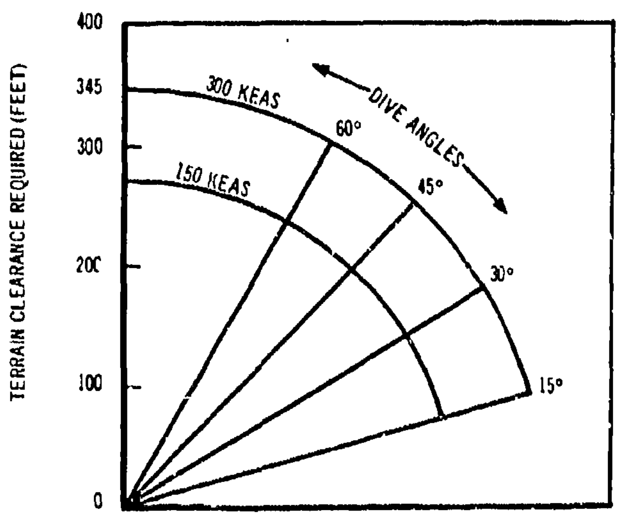


Figure 55. LW-1 Dive Angle Capability

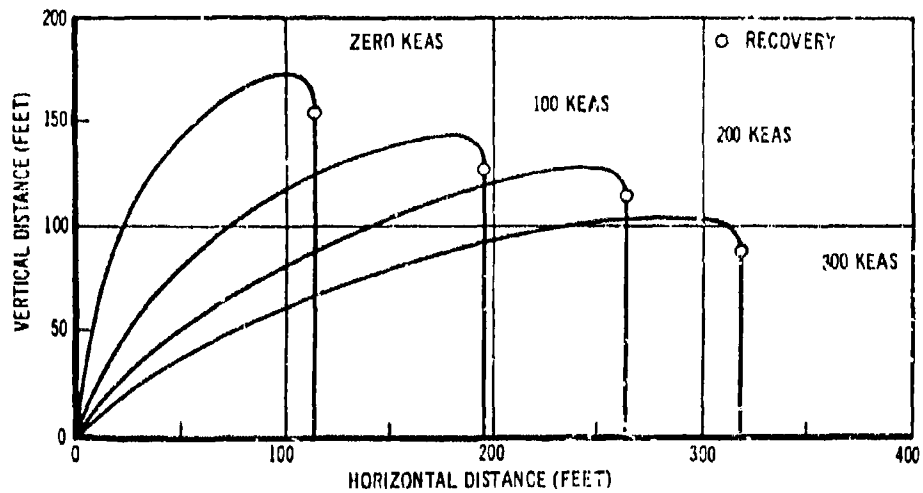


Figure 56. LW-1 Predicted Trajectories

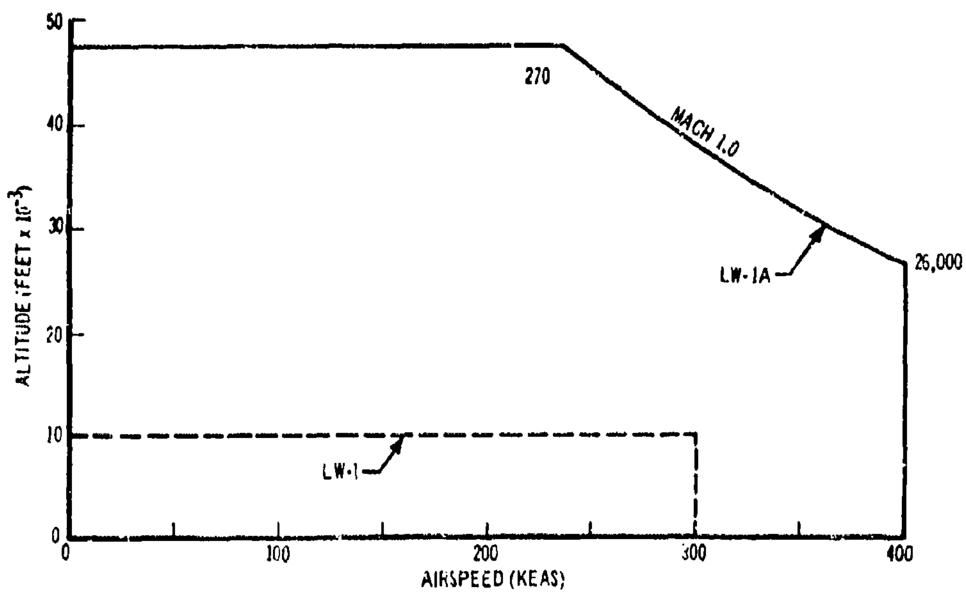


Figure 57. LW-1 Design Performance Envelope

Table VIII. North American LW-1 Seat Escape System Weight Breakdown

	Weight (Lb) LW-1	Weight (Lb) LW-1A
Fifty percentile man	167.0	167.0
Clothing	10.0	10.0
Parachute and harness	22.6	22.6
Emergency equipment	4.5	37.1
Total man and equipment	204.1	236.7
Seat	49.7	61.2
Total Weight (Ejectable)	253.8	297.9
Nonejectable mechanism	17.3	28.4
	271.1	326.3
Total Weight (Supported by parachute after separation)	192.1	2[illegible].0 (approx.)

seat results in a capability of sustaining 40 g crash loads. The seat vertical adjustment provision consists of rail-mounted screw jacks and a worm gear driven by either a hand crank or a flexible shaft from a 3,000 ft/lb electric actuator. A modified B-4 integrated harness is used with the seat. The ballistic inertia reel, which has a manual lock handle, is actuated by one of the two T31E1 initiators. The speed sensor (Pacific Scientific Co., P/N 1201103-0) is mounted on the nonejectable structure and has air lines connected to it from the airplane pitot static and dynamic pressure system. At speeds below 300 KEAS the speed sensor pin is extended in such a manner that the aneroid device arming pin is mechanically extracted as the seat moves up the rails; at speeds above 300 KEAS the speed sensor pin is retracted. At any airspeed, as the seat moves up the rails the one-second delay MK IV Mod 0 cartridge is actuated by a mechanical trip, and when the cartridge fires it causes extraction of the aneroid device arming pin.

The aneroid device is a qualified Speidel Corporation P/N 63-104-A Type II unit that fires the parachute drogue gun. When the aneroid arming pin is extracted, the aneroid immediately fires the drogue gun at ejection pressure altitudes less than 10,000 feet. At ejection pressure altitudes greater than 10,000 feet, the aneroid mechanism prevents drogue gun firing until descent to 10,000 feet pressure altitude. The oxygen bottle is a Firewel Company P/N F151309 having [illegible] cubic inches volume and pressurized to 1,800 psi, which provides adequate oxygen for descent from 47,500 feet altitude with the parachute fully inflated.

j. NORTH AMERICAN LW-2, LW-2A, AND LW-2D SEATS

The North American LW-2, LW-2A, and LW-2D seats are essentially the same rocket-catapult, open-type, upward ejection seat. The LW-2 seat was designed for high-performance VTOL and STOL U.S. Army aircraft and was developed under contract for use in the XV-5A G.E.-Ryan fan-in-wing and Lockheed XV-4A Hummingbird aircraft. It is currently used in, or programmed for, the XV-4A, XV-5A, Curtiss-Wright X-19, and North American YAT-28E. The LW-2 seat has escape capability at zero to 500 KEAS from ground level to 50,000 feet altitude, with a limitation of Mach 2.0 within this

envelope. The LW-2A seat is an LW-2 seat, modified to accommodate the USAF type personnel harness and USAF survival equipment. The LW-2D seat is an LW-2 seat with a modified event timing sequence to permit ejections at 500 to 650 KEAS at altitudes as low as 50 feet above ground level, in addition to the LW-2 seat capability. Also, the LW-2D seat has an energy absorption system to prevent vertical crash loads greater than 20 g.

The LW-2 seat has a survival kit located in the seat bucket, an emergency harness release handle located on the right-hand side of the headrest, a D-ring ejection handle located on the front of the seat bucket, a ballistic inertia reel located on the seat back, a rocket-catapult located between the rails, a canopy cutter located on top of the headrest, a speed sensor located on the nonejectable structure, an aneroid device located near the headrest, a drogue gun and 52-inch diameter ribless guide surface stabilization parachute located near the headrest, a harness release actuator, and a 28-foot standard flat canopy main recovery parachute with a PA-7 pilot chute packed in a long, cylindrical bag located on the left-hand side of the seat back. The LW-2 seat, less the canopy cutter, is shown in Fig. 58, and Fig. 59. These figures show the seat envelope and the ballistic system schematic.

Ejection is initiated by pulling the D-ring ejection handle, which fires two T-30E2 initiators. Pressure from one initiator fires the ballistic inertia reel and one catapult time delay, and pressure from the other initiator fires a redundant time delay in the catapult. The inertia reel positions and restrains the seat occupant during the catapult time delay. After the 0.3 second catapult time delay the catapult propels the seat up the ejection rails, the canopy cutter cuts through the canopy, and the rocket is ignited just prior to catapult tube separation. The LW-2 seat two-mode selector system is shown in Fig. 60.

At speeds less than 200 knots and at altitudes below 10,000 feet, the personnel parachute is deployed following a 0.2 second delay, initiated during seat movement up the rails. This is accomplished by a low-speed striker hitting the extended speed sensor pin and firing the ballistically propelled thruster slug attached to the personnel parachute, thereby providing positive deployment of the parachute approximately 0.1 second after the seat leaves the airplane. The man is positively separated from the seat by the personnel parachute after the 0.5 second harness release time delay (initiated by the striker actuation described above) has expired.

At speeds greater than 200 knots and altitudes below 10,000 feet, the thruster slug deploys the drogue parachute as the seat moves out of the cockpit, thus providing immediate seat stability as it enters the windstream. The drogue chute is attached to the seat by three risers; two attach to the bottom of the seat, one attaches to the top of the seat, and all meet at a confluence point. After expiration of the 0.5-second harness release delay, the lower risers are released from the seat, and the seat is rotated head aft. This allows the top riser to be released from the seat, and the drogue chute then deploys the personnel chute. Inflation of the personnel chute pulls the man from the seat.

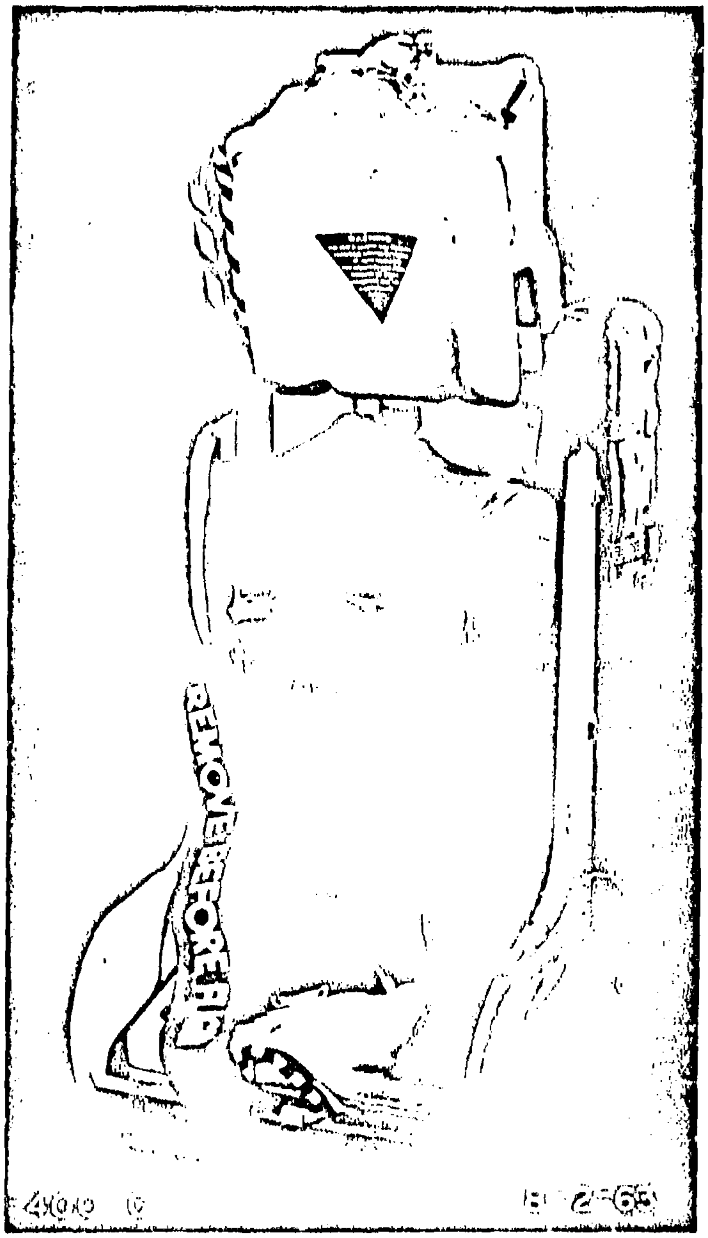


Figure 58. LW-2 Seat, Less Canopy

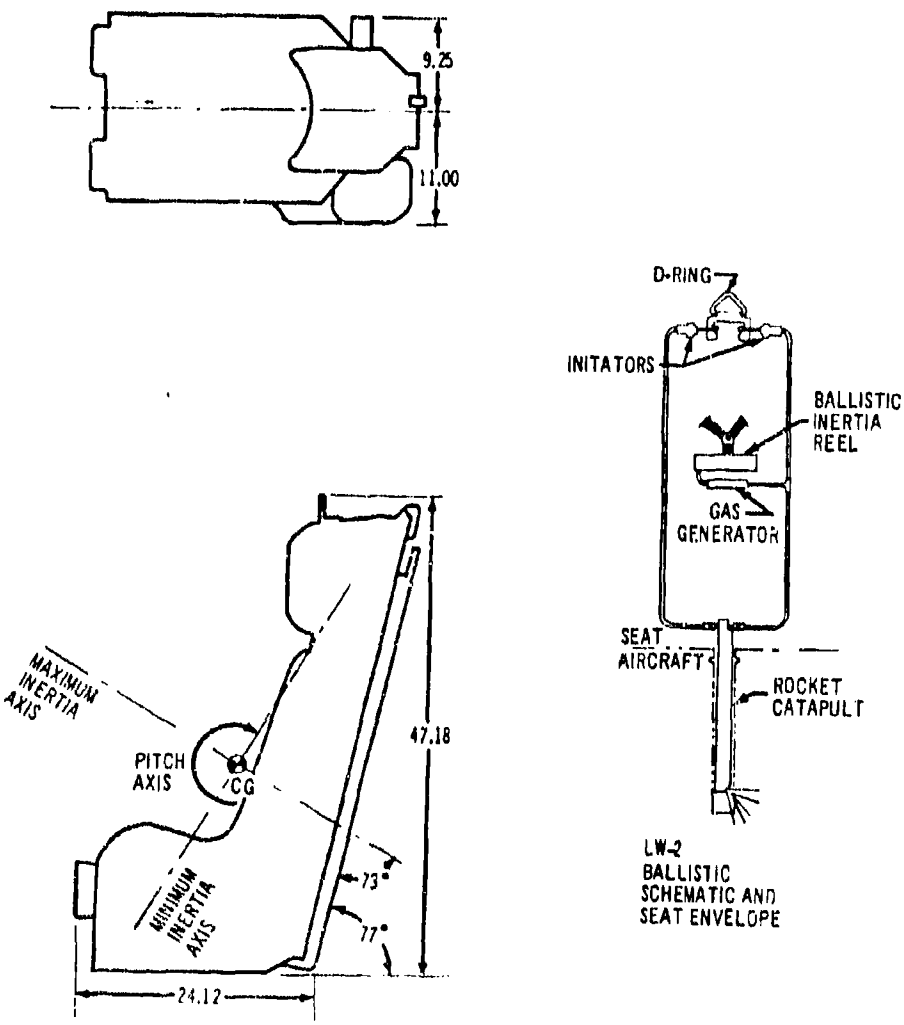


Figure 59. LW-2 Ballistic Schematic and Seat Envelope

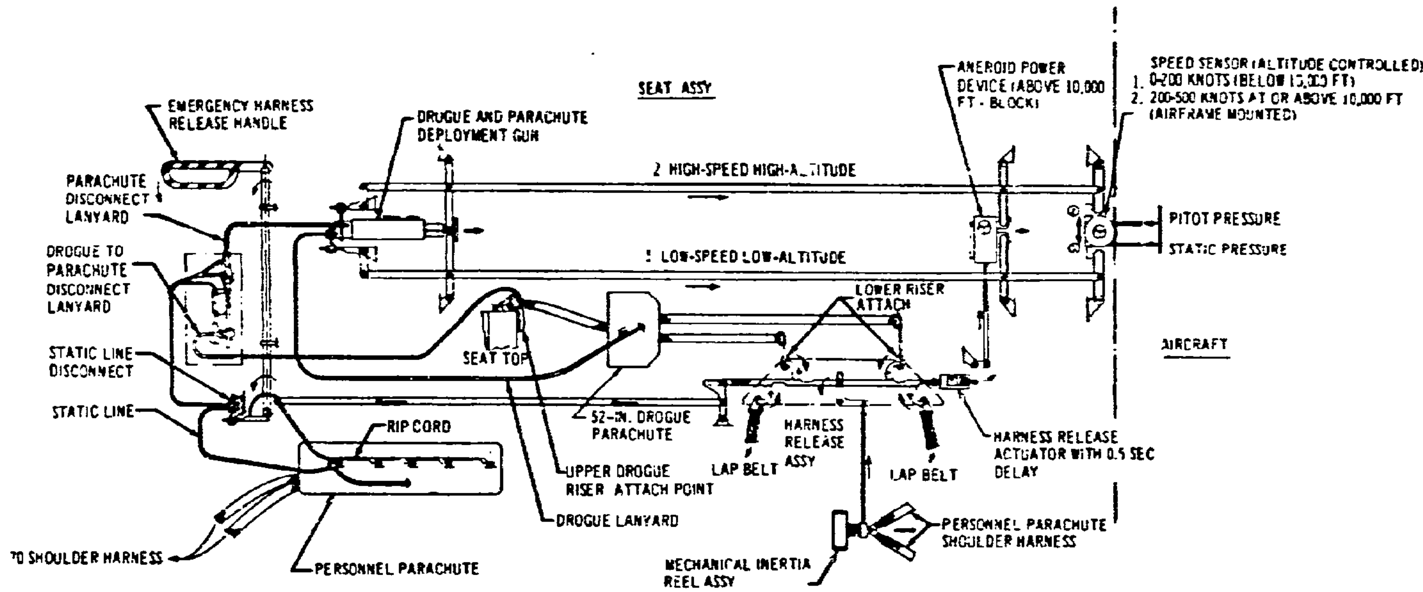


Figure 60. LW-2 Two-Mode Selector System

At altitudes above 10,000 feet the drogue chute is always deployed for seat stability. Initiation of the 0.5-second harness release time delay is blocked by the aneroid unit until descent to 10,000 feet. After expiration of the 0.5-second delay, drogue release, harness release, and deployment of the personnel parachute is accomplished as described for high-speed ejections. In all cases, seat-man separation is effected by personnel parachute drag.

Performance of the LW-2 seat has been demonstrated by static tests, sled tests, laboratory tests, and operational experience. These tests were conducted with 5 and 95 percentile anthropometric dummies to demonstrate successful performance when the ejected seat-man mass, center of gravity, and moment of inertia is varied. Catapult forces are less than 12 g with rates of onset less than 250 g/second. As a result of these tests, the 0.2-second delay in personnel chute deployment was incorporated to preclude rocket blast fusing the chute. Personnel chute shroud line stowage was changed from hesitator loops requiring 15 to 90 pounds pull force to pivoting sleeves that require a maximum pull force of only 10 pounds. Figure 61 is a composite photograph of a static ground test ejection. Sink rate recovery capability is shown in Fig. 62, dive angle recovery capability is shown in Fig. 63, typical ejection trajectories are shown in Fig. 64, and the performance envelope is shown in Fig. 65.

The LW-2D seat has undergone sled tests and static firings that demonstrate its ability to be ejected through the XV-5A, X-19, and YAT-28E canopies.

The LW-2D seat escape event time history is shown in Table IX.

Table IX. North American LW-2 Time History of Events

Above 200 Knots		Below 200 Knots	
Time (Sec)	Event	Time (Sec)	Event
0.00	Escape system initiation, canopy jettisoning system, and ballistic inertia reel actuation	0.00	Escape system initiation, canopy jettisoning system, and ballistic inertia reel actuation
0.3	Crewman positioned	0.3	Crewman positioned
0.4	Catapult ignition	0.4	Catapult ignition
0.49	Drogue gun firing, drogue chute deployment	0.49	Drogue gun delay ignition
0.55	Rocket ignition	0.55	Rocket ignition
0.56	Seat-aircraft separation	0.56	Seat-aircraft separation
0.83	Rocket burnout	0.70	Drogue gun firing, personnel chute deployment
1.39	Harness release actuation, drogue chute release actuation	0.83	Rocket burnout
		1.39	Harness release actuation
2.5	Full personnel chute inflation, based on 600 KEAS ejection	1.8	Full personnel chute inflation, based on 200 KEAS ejection

Figure 61. LW-2 Static Ground Test Ejection

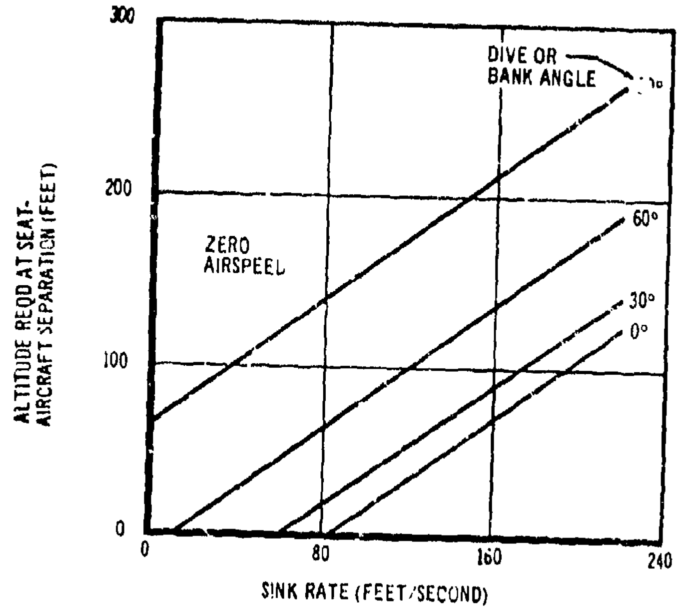


Figure 62. LW-2 Sink Rate Recovery Capability

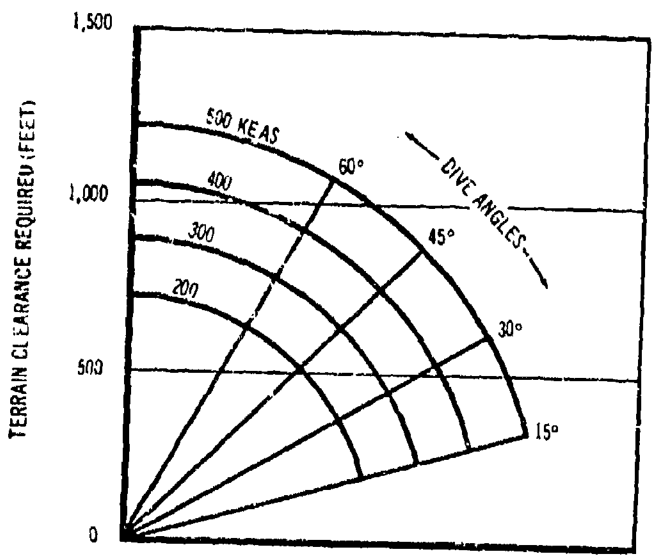


Figure 63. LW-2 Dive Angle Capability

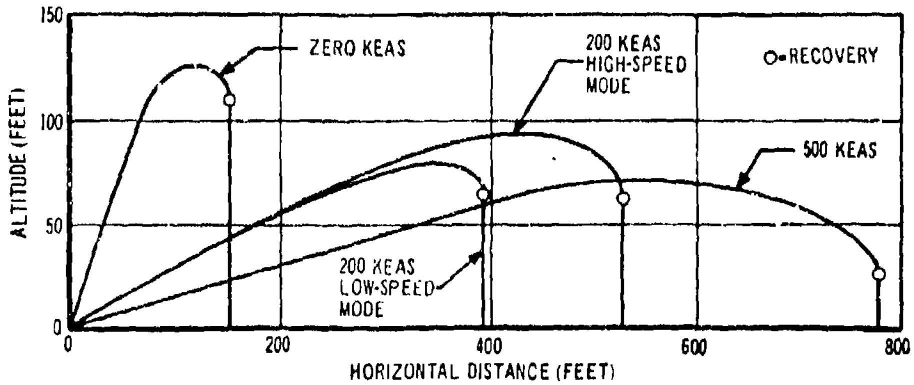


Fig. 64. LW-2 Predicted Trajectories

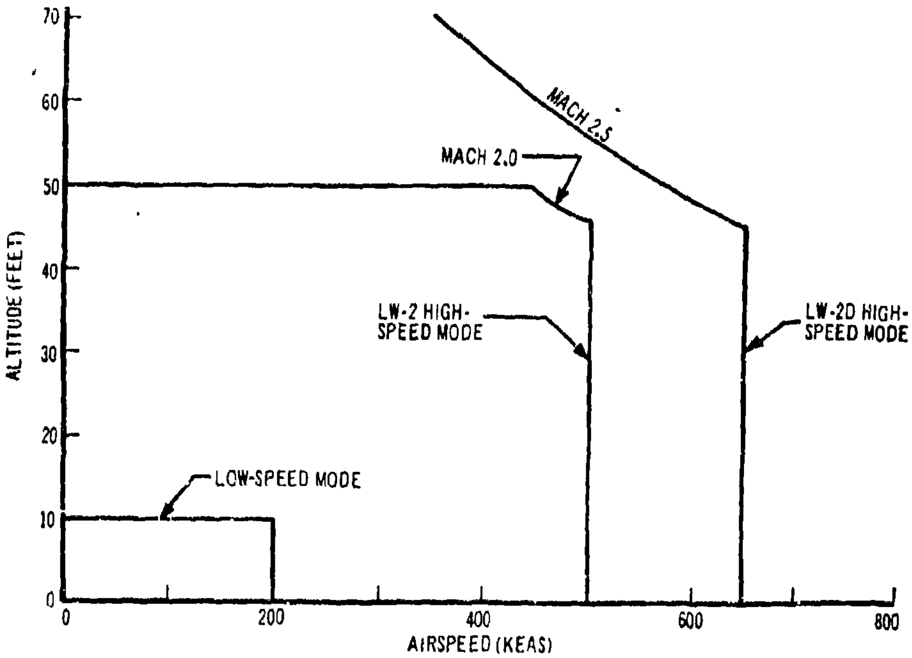


Figure 65. LW-2 Performance Envelope

The basic difference in the LW-2 and LW-2D timing sequence is in the seat harness release actuator, which has a 0.5-second delay on the LW-2 seat and an 0.75-second delay on the LW-2D seat. The system weight breakdown is shown in Table X.

Table X. North American LW-2 Seat Escape System Weight Breakdown

		Weight (Pounds)
Basic seat		89.0
Survival equipment		49.0
Parachute	22.0	
Harness	3.4	
Survival kit with oxygen	21.9	
Lap belt	1.7	
Ejectable ballistic items		13.3
Rocket	12.4	
Miscellaneous cartridges	0.9	
Ninety-Five percentile man and clothing		208.0
Total ejectable weight		359.3
Aircraft installation		19.3
Bulkhead fittings	9.0	
Speed sensor	0.7	
Catapult	9.6	
Total Weight (Installed)		378.6

The ejected seat-man moments of inertia for axes shown on Fig. 59 are:

Percentile Man	Maximum	Minimum	Pitch
95 Percentile	75,150 $lb\text{-}in^2$	26,260 $lb\text{-}in^2$	81,685 $lb\text{-}in^2$
5 Percentile	64,883 $lb\text{-}in^2$	25,750 $lb\text{-}in^2$	63,492 $lb\text{-}in^2$

k. NORTH AMERICAN LW-3B SEAT

The LW-3B seat was being qualified as of February 1965 for the U.S. Navy for use in the OV-10A airplane. A demonstration of the system at speeds from 0 to 461 KEAS at ground level was scheduled to be completed in July 1965. This system is an outgrowth of the North American LW-1 and LW-2 escape systems. The LW-1 meets the escape requirements of flying platforms and low-speed V/STOL aircraft. The LW-3B seat complies with the escape requirements of medium speed V/STOL aircraft. It will recover a crewman ejecting at zero altitude at all speeds from 0 to 500 KEAS. In addition, it provides recovery when ejecting at or near zero altitude from an airplane

having a high sink rate or nosedown attitude at time of ejection. The seat recovery envelope is shown in Fig. 66. The seat space envelope is shown in Fig. 67. The general arrangement of the seat is shown in Fig. 68. An exploded view of the seat is shown in Fig. 69.

Pulling the D-ring initiates an automatic escape sequence. The canopy is jettisoned, the 0.4-second delay in the catapult is fired, and the ballistic inertia reel is actuated. The catapult delay allows canopy removal and crewman positioning and restraint before the catapult fires. If the canopy fails to jettison, the crewman will be ejected through the canopy without a delay in the escape sequence. A schematic of the LW-3B sequencing system is shown in Fig. 70. When using this system, the copilot is automatically ejected by the pilot when the pilot initiates ejection. However, the copilot can eject himself at any time without ejecting the pilot.

The LW-3B is a two-mode system. The mode is selected at the time of ejection by a speed sensor, U.S. Navy P/N 1201142. At altitudes below 10,000 feet and at speeds less than 200 knots, the recovery parachute is ballistically deployed immediately after the seat leaves the aircraft. At speeds greater than 200 knots and/or at altitudes above 10,000 feet, a delay in the parachute thruster allows the seat to decelerate to a velocity safe for recovery parachute deployment. In both the low and high-speed mode, seat-man separation is effected by inflation of the recovery parachute. The U.S. Navy NB-7 recovery parachute utilizes a standard, 28-foot flat, circular canopy, and a conventional, spring-loaded pilot chute. The time history of events for the two-mode system is given in Table XI.

Table XI. North American LW-3B Time History of Events

Low Speed (Sec)	Low Speed Event	High Speed (Sec)	High Speed Event
0.00	Escape system initiation, canopy jettisoning system, and ballistic inertia reel actuation	0.00	Escape system initiation, canopy jettisoning system, and ballistic inertia reel actuation
0.30	Crewman positioned	0.30	Crewman positioned
0.40	Catapult ignition	0.40	Catapult ignition
0.51	Parachute thruster delay ignition	0.53	Parachute thruster delay ignition
0.55	Rocket ignition	0.55	Rocket ignition
0.56	Seat-aircraft separation	0.56	Seat-aircraft separation
0.64	Thruster firing, parachute deployment	0.83	Rocket burnout
0.83	Rocket burnout	2.53	Thruster firing, parachute deployment
1.10	Seat-man separation.	3.34	Seat-man separation.
1.50	Full parachute inflation. (Based on 200 KEAS ejection.)	3.70	Full parachute inflation. (Based on 500 KEAS ejection.)

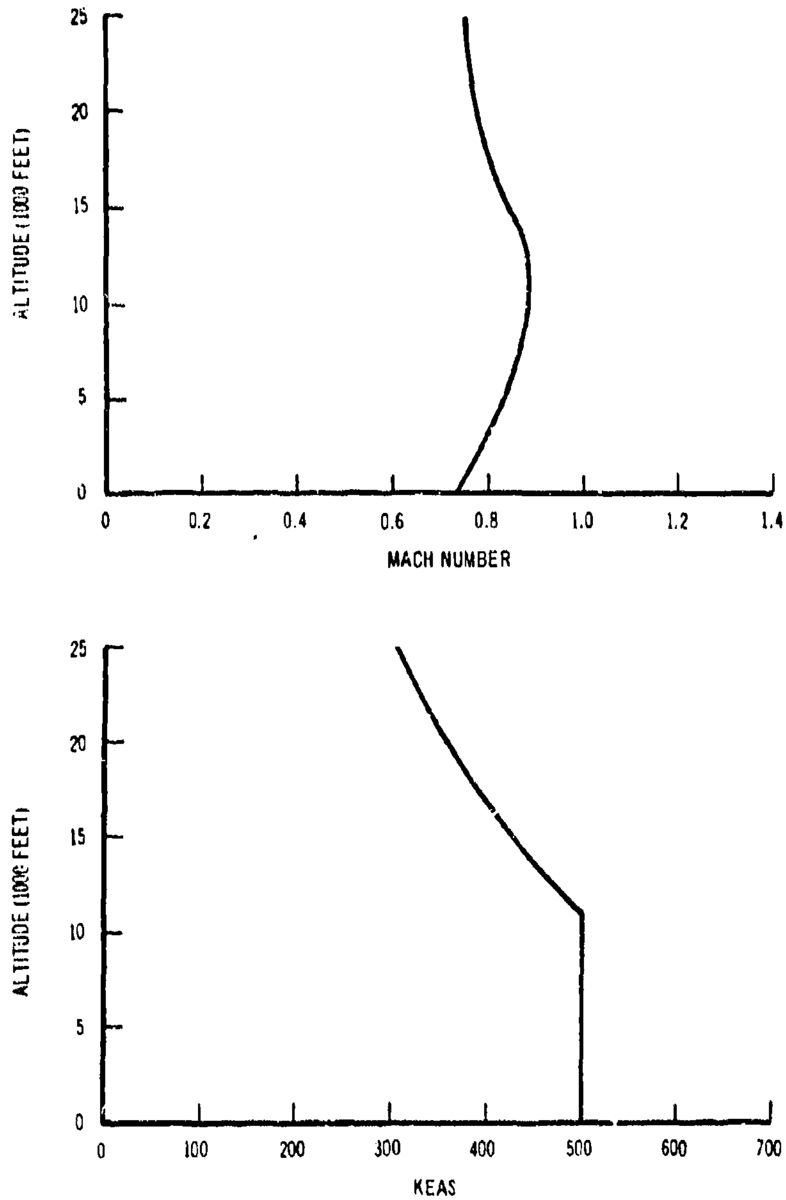


Figure 66. North American LW-3B Seat – Recovery Envelope

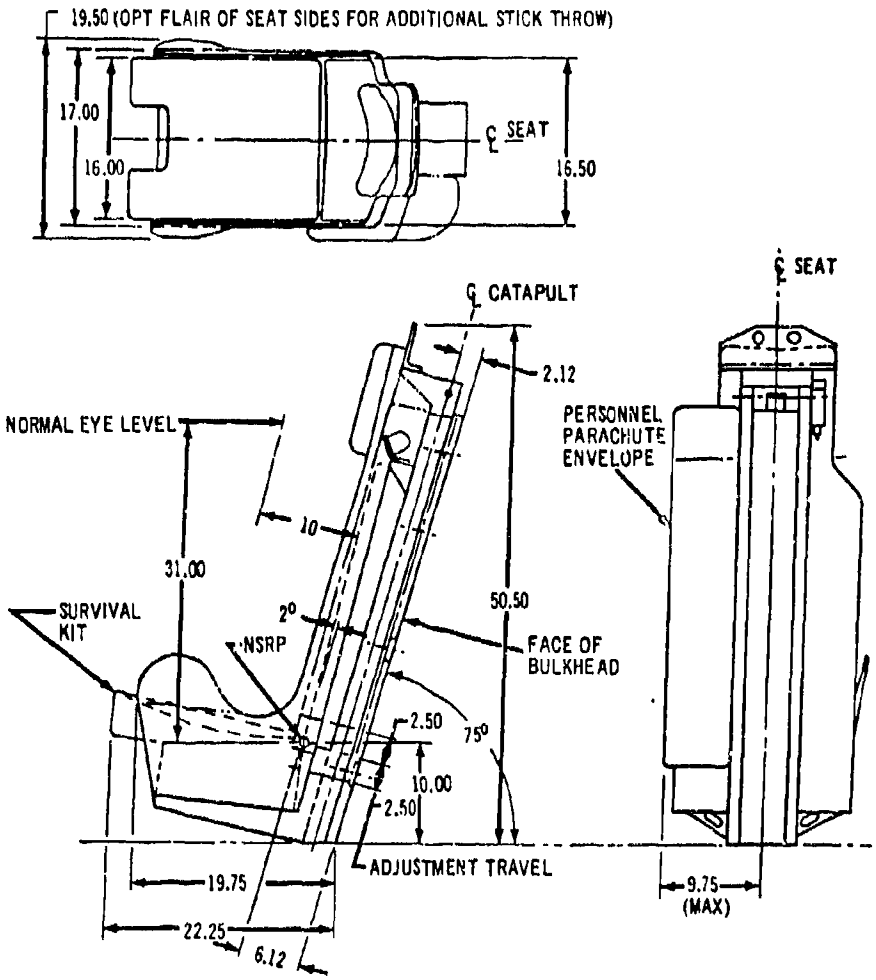


Figure 67. North American LW-3B Seat – Space Envelope

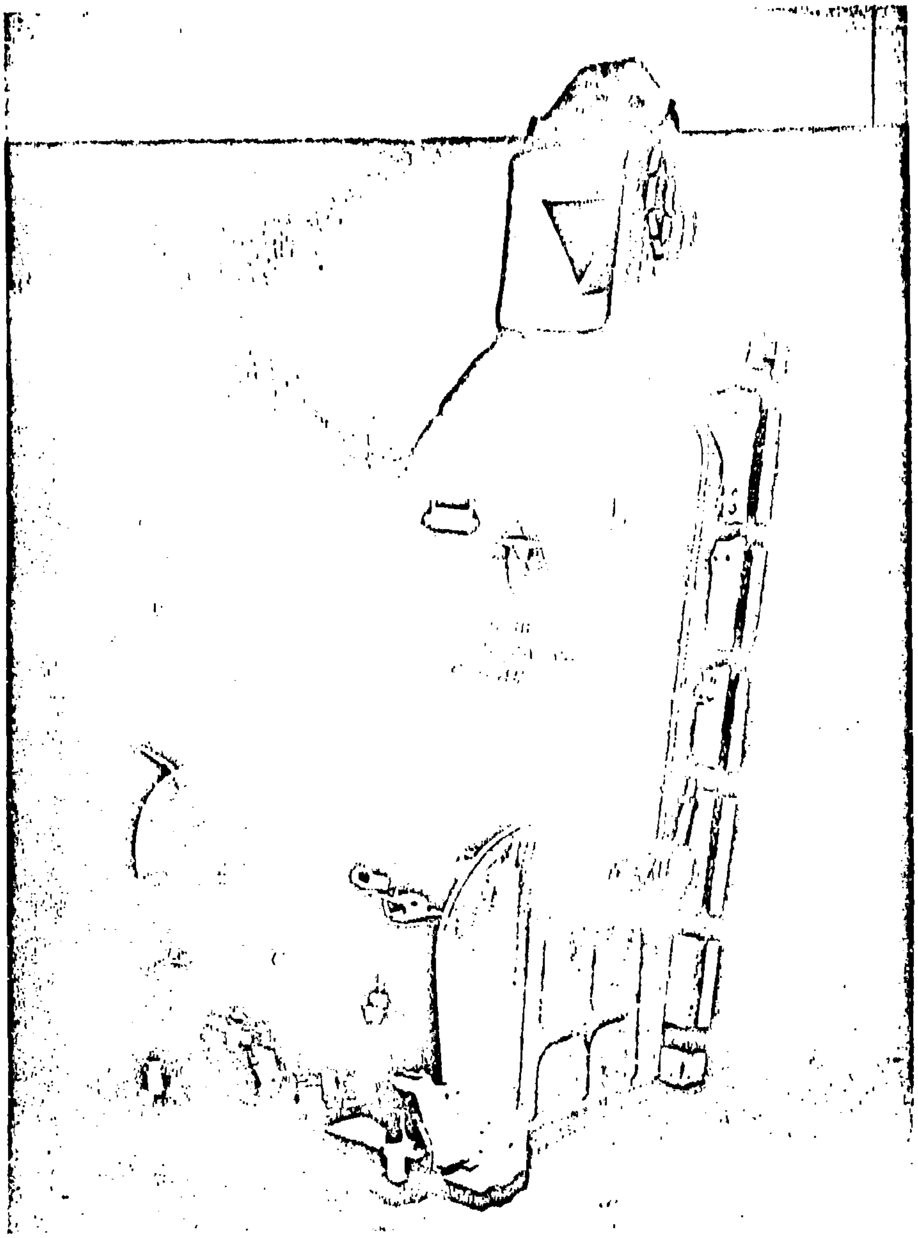


Figure 68. North American LW-3B Seat – General Arrangement

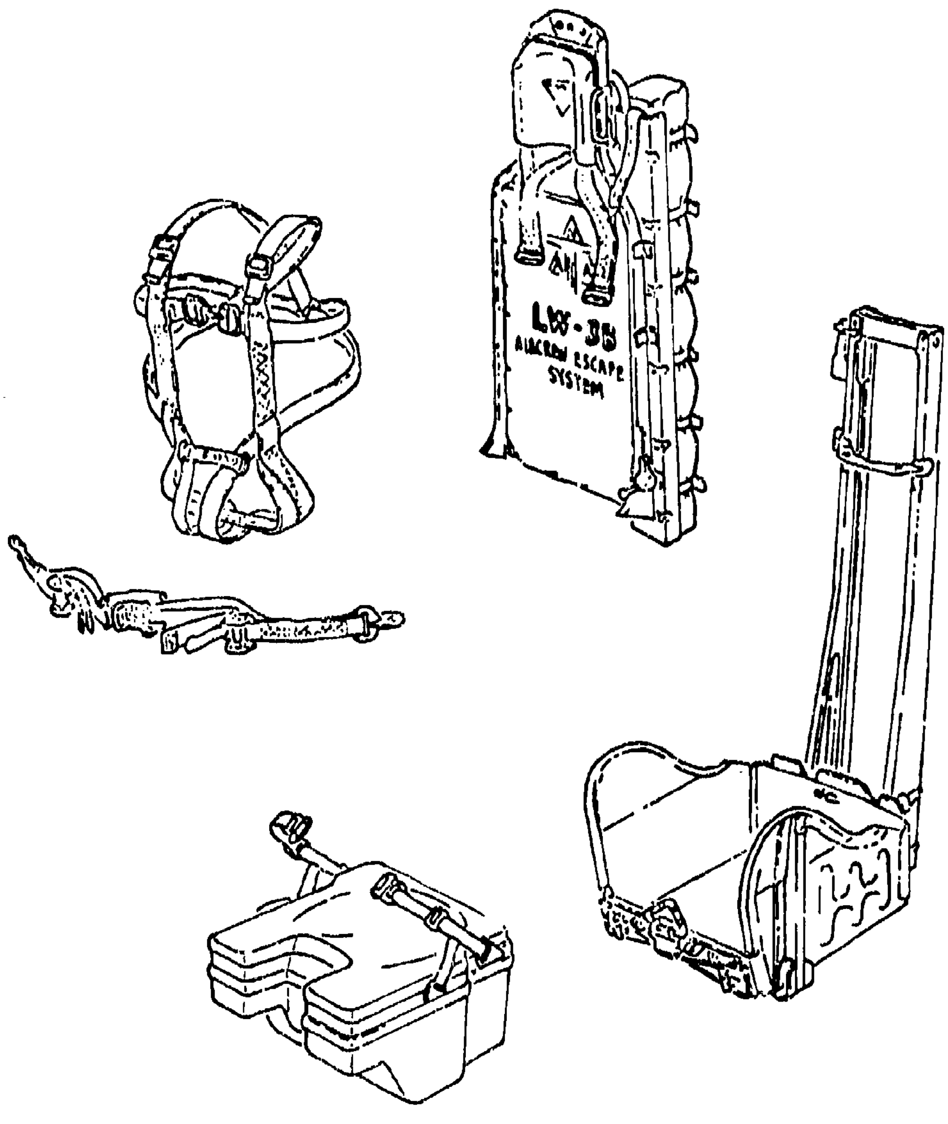


Figure 69. North American LW-3B Seat – Exploded View

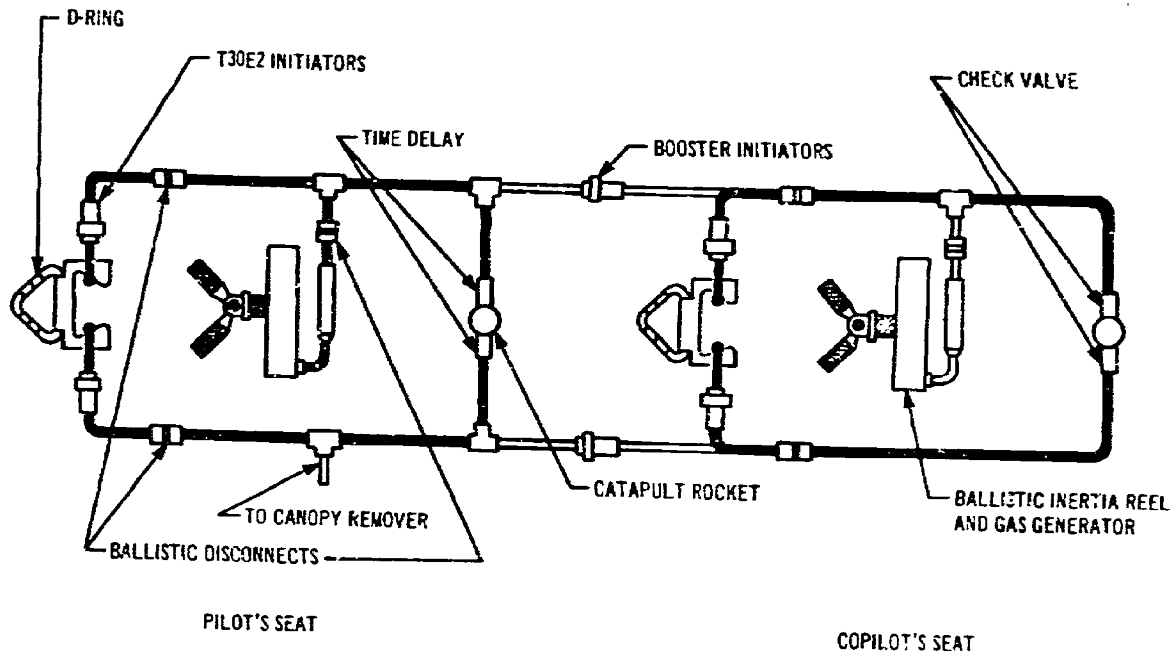


Figure 70. North American LW-3B Seat – System Schematic

Additional recovery capability at altitude can be achieved by the addition of a seat aneroid. The recovery envelope with a seat aneroid added is shown in Fig. 71. In this system, the long time delay in the parachute thruster is not fired, but instead the aneroid is armed. The aneroid immediately fires the long time delay if below 10,000 feet. If above 10,000 feet, the aneroid will not fire the long time delay until the seat descends to 10,000 feet.

The LW-3B seat is designed to accommodate a U. S. Navy RSSK-6A survival kit or equivalent.

Peak catapult forces range from 12-15 g with the rates of onset of acceleration from 150-180 g/second.

Representative recovery trajectories are shown in Fig. 72. Table XII gives the seat escape system estimated weight breakdown.

Table XII. North American LW-3B Seat Escape System Estimated Weight Breakdown

Item		Weight (Lb) 5 Percentile	Weight (Lb) 95 Percentile
Ejected portion of seat (Includes basic seat structure, rocket motor, initiators, hose assembly, thruster gun, mechanical inertia reel)		61.75	61.75
Nonejected seat provisions (Includes catapult rocket launch tube, electrical seat actuator, attachment bulkhead seat guide fittings)		18.50	18.50
Total seat components		80.25	80.25
Survival equipment		52.90	52.90
Parachute	21.90		
Survival container and equipment	31.00		
Man		133.00	201.00
Flying apparel		20.00	20.00
Total (Seat installation)		286.15	354.15
Total Weight (Ejectable)		267.65	335.65

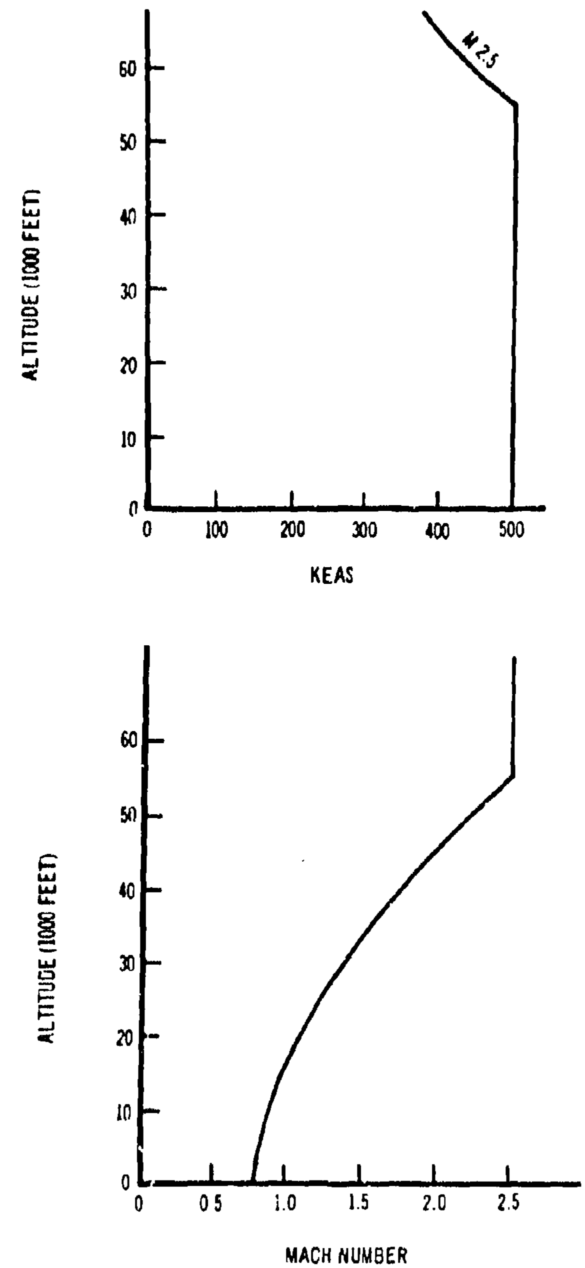


Figure 71. North American LW-3B Seat – Recovery Envelope with Seat Aneroid Added

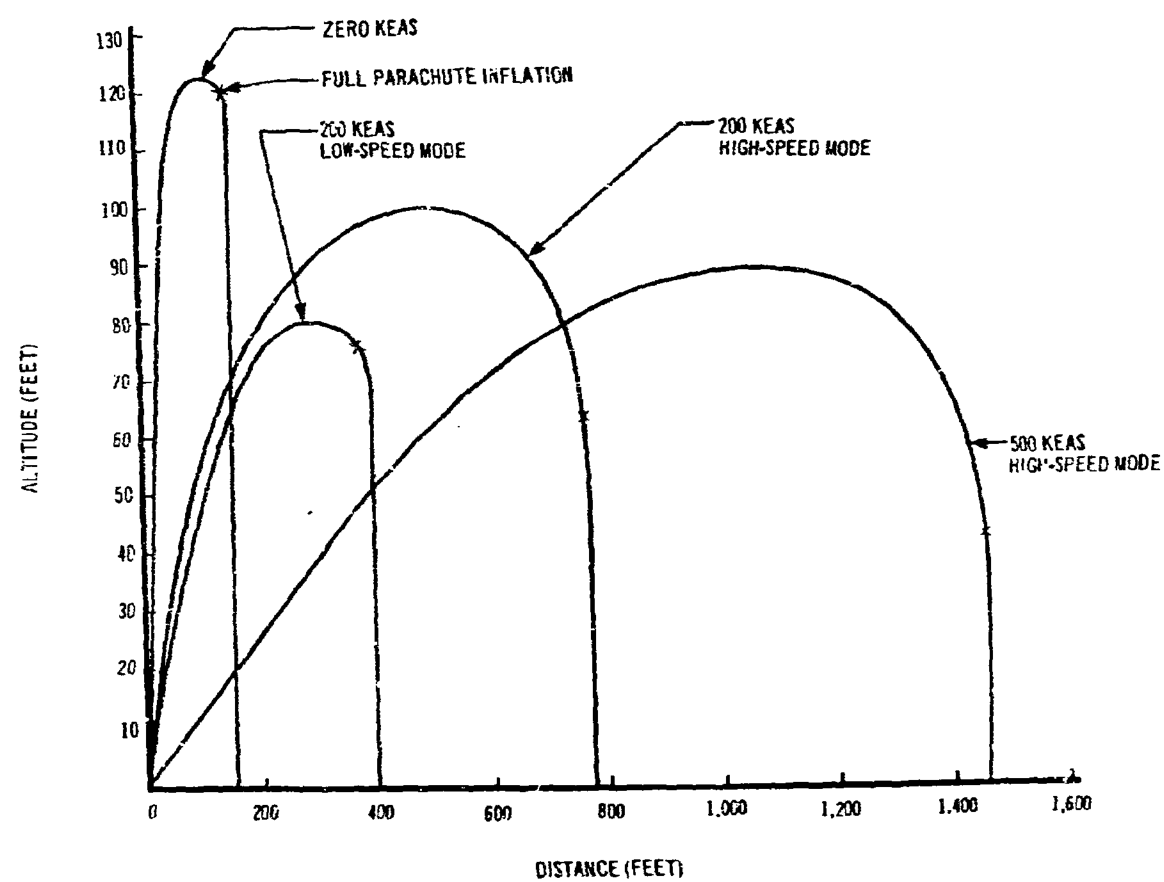


Figure 72. North American LW-3B Seat Representative Recovery Trajectories

1. WEBER F-106 SEAT

The ejection seat escape system described in this section is an improved version of the original interim upward ejection seat used in F-106 aircraft prior to the availability of the Convair "B" seat supersonic escape system. The modified F-106 upward ejection seats were developed and manufactured by the Weber Aircraft Corporation in 1964 and 1965 for installation in F-106A/B aircraft as a replacement for the "B" seat supersonic escape system. The reason for the change was to improve the reliability and low altitude escape capability of the F-106 escape system.

The modified F-106 upward ejection seat escape system consists of the canopy jettison system, ejection initiation and eject sequence installation, rocket catapult, lap belt and shoulder harness, inertia reel (powered inertia reel on aft seats), arm guards, vertical seat adjustment, rotary actuator and strap type seat-man separator, 1800 cu in. global survival kit, and modified B-18 parachute with Weber cartridge actuated deployment gun and aneroid block. Figure 73 shows a typical F-106 A/B modified upward ejection seat. Figure 74 is an outline drawing giving overall dimensions of the seat, and Table XIII is a weight statement with a breakdown of the major components.

Table XIII. F-106 Ejection Seat Weight Breakdown

Ejectable	Weight (Lb)
Seat structure	78.68
Inertia reel with shoulder straps	2.1
MA-5 lap belt	3.0
Seat-man separator	3.75
Modified BA-18 parachute pack with C-9 canopy and drogue gun	27.0
RPI 2174-518 rocket-catapult - without shell	22.5
USAF survival kit	36.5
	173.53
Nonejectable	
Track assembly	25.5
Ballistic hose disconnects	1.75
Seat adjustment actuator	6.1
Rocket catapult shell 2174	5.5
	38.85
Total Weight	212.38

Ejection sequence schematic diagrams for the F-106A and F-106B aircraft modified ejection seat escape systems are shown on Figs. 75 and 76. A single mode eject sequence is provided for the single place F-106A aircraft. For the two-place tandem seating arrangement of the F-106B a two mode eject sequence is required to ensure that the aft seat always ejects prior to forward seat ejection to prevent rocket-catapult blast injury to the aft seat occupant. Thus, if escape is initiated from the forward seat position, the aft seat occupant is automatically positioned by a powered shouldered harness

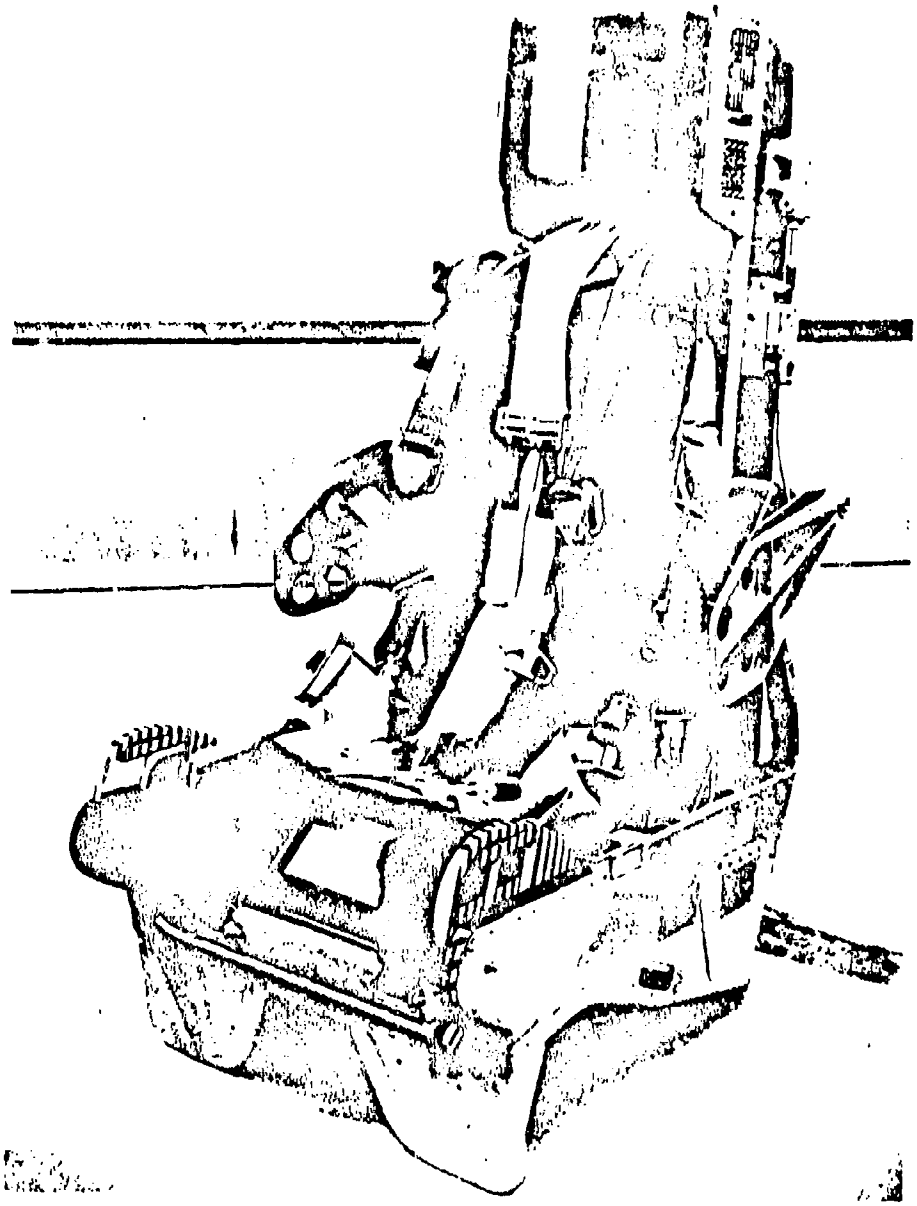


Figure 73. F-106 Modified Upward Ejection Seat

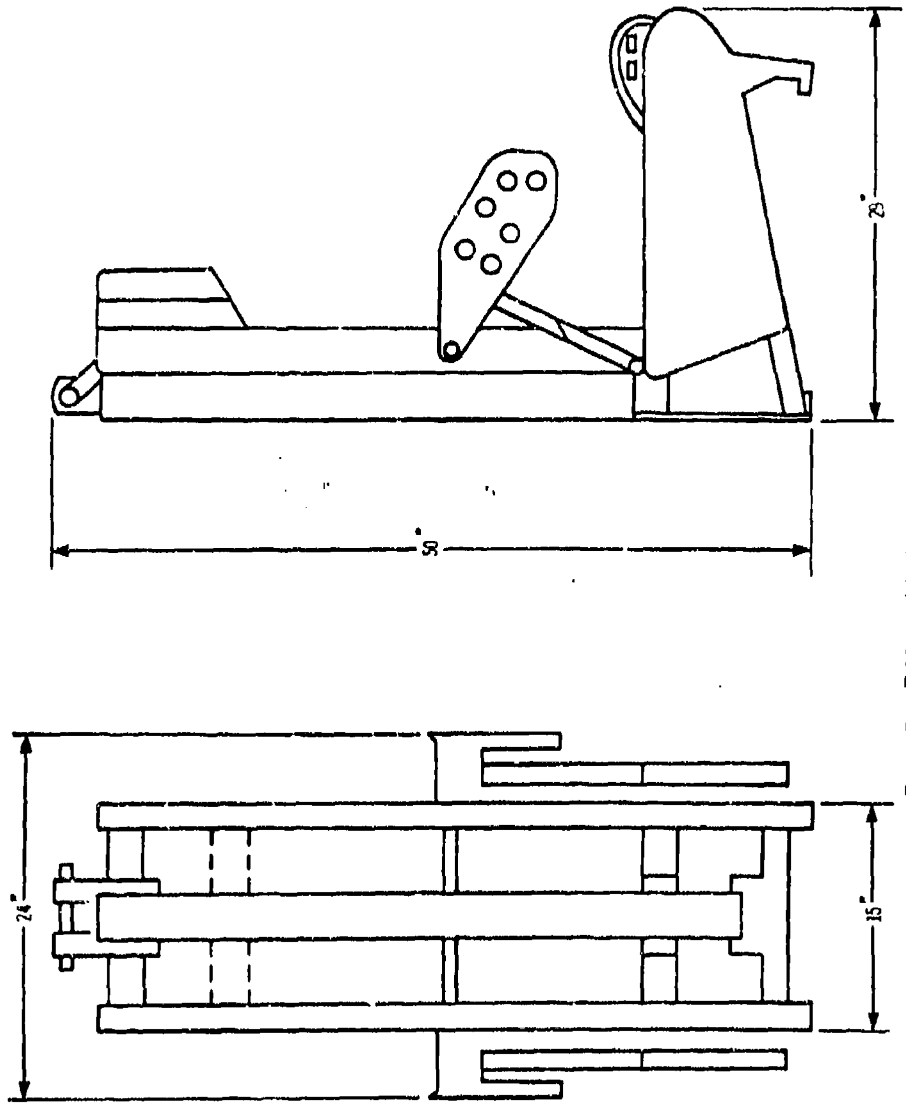


Figure 74. F-106 Modified Upward Ejection Seat

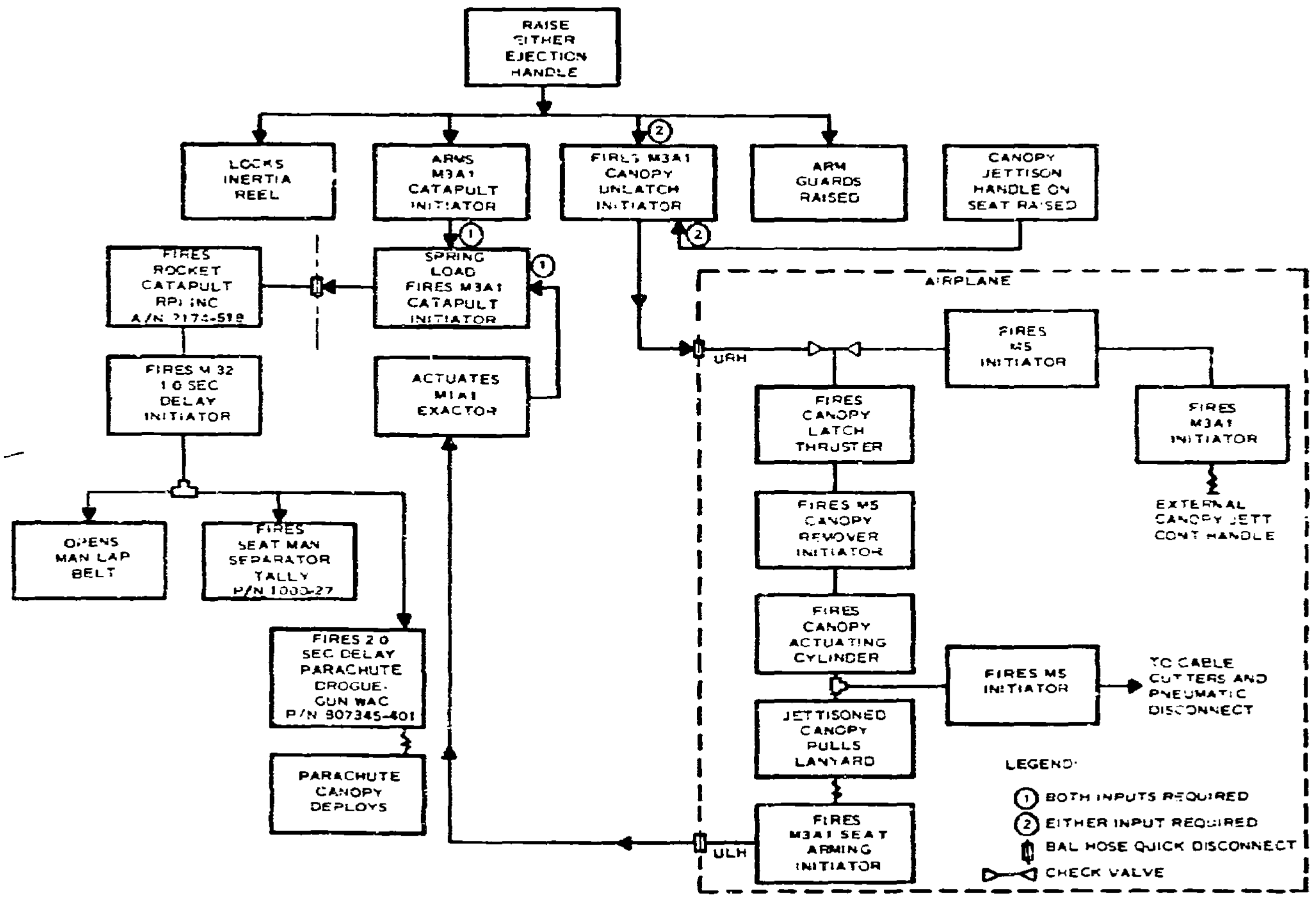


Figure 75. F-106A Pilot's Ejection Seat – Ejection System Sequence Schematic

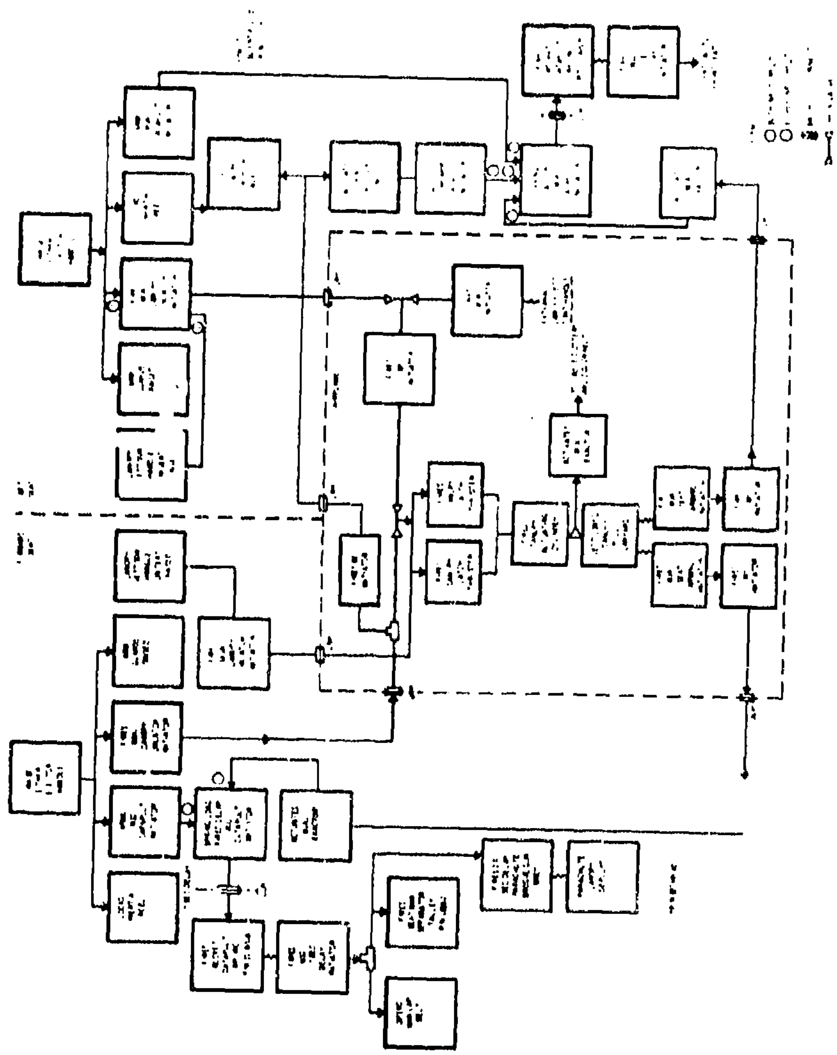


Figure 76. F-106B Pilot's Ejection Seat – Ejection System Sequence Schematic

inertia reel and is ejected from the aircraft. The forward seat then automatically ejects one second after ejection of the aft seat. The aft seat may be independently ejected at any time without affecting the forward seat.

Following is the sequence of events that occurs during emergency escape for the F-106A modified upward ejection seat escape system:

Squeezing the handgrip release trigger and raising either of the two ejection control handles on the seat causes the following events:

- Locks shoulder harness inertia reel
- Causes spring-loaded arm guards to rota[illegible]ised position
- Releases M3A1 catapult initiator safety lock
- Fires canopy unlatch M-3A1 initiator
- Firing of the canopy unlatch initiator results in the jettisoning of the canopy.
- As the canopy separates from the aircraft, a lanyard attached to the canopy fires an M3A1 initiator. This actuates an M1A1 exactor, releasing a spring load which fires the M3A1 catapult initiator.
- The catapult initiator fires the rocket catapult causing the seat to be ejected from the aircraft.
- As the seat travels up the fixed ejection rails it fires the M-32 one second delay lap belt initiator.
- After the one second delay, gas pressure from the M-32 initiator causes the lap belt and shoulder harness to release, fires the seat-man separator ballistic rotary actuator, and actuates the two second delay, Weber power-actuated-gun deployed parachute system.
- The rotary actuator mounted on the top rear of the seat retracts straps which are initially routed behind the pilots parachute pack, under the survival kit, and attached to the front of the seat bucket. This forcibly separates the crewman from the seat.
- Two seconds after seat-man separation, a modified BA-18 personnel parachute is deployed by a Weber aneroid controlled deployment gun. A detailed description of the Weber power-actuated-gun deployed parachute system is presented in the subsystems section of this report.

The F-106A/B modified upward ejection seats were designed to provide escape at zero-speed and zero-altitude, and at all speeds up to 600 knots IAS at ground level. Developmental and demonstration static and sled tests have been accomplished to prove the system capability throughout this speed range. Some typical ejection seat trajectories taken from sled test data are

shown in Fig. 77. No special stabilization devices are provided for the F-106A/B ejection seats. Trajectory height and low-level recovery capability of the ejection seat system is dependent upon the seat pitch attitude during rocket burn time. Therefore, to attain adequate attitude control, close control of the seat-man center of gravity relative to rocket thrust line is required. In the F-106 seat, the line of rocket thrust is adjusted to cause the seat to pitch aft, thereby attaining a greater vertical thrust component and greater trajectory height. Tests have demonstrated that seat-man center of gravity variations between the use of 5 to 95 percentile crewmen are within the tolerance limits required for successful recovery.

m. WEBER EJECTION SEAT (T-37)

The T-37 lightweight ejection seat was developed and manufactured by the Weber Aircraft Corporation for the Cessna Aircraft Company. The T-37 lightweight ejection seat system provides safe escape for a crewman at ground level to 40,000-feet altitude and at speeds from 120 to 400 knots IAS. The general arrangement of the seat is shown in Fig. 78 and the major installation dimensions are shown in Fig. 79.

The pre-ejection functions are initiated by raising the arming handles (leg braces), located on each side of the seat, to the full up position where they are locked. This action positions the catapult firing trigger, locks the shoulder harness and causes the canopy to be jettisoned. Squeezing the ejection trigger fires the catapult. As the seat leaves the aircraft, the M 12 one-second delay initiator is fired to open the lap belt and release the shoulder harness enabling the occupant to separate from the seat. (Note: This seat has been modified to include seat-man separation capability.) Automatic opening of the BA-15 parachute with C-9 canopy is controlled by an F-1B type parachute timer and aneroid block which is activated by the occupant's separation from the seat. When activated above the preset altitude, the parachute pack remains closed until the preset altitude is reached, then after a one-second timer delay, the parachute pack is opened. Figure 80 is a schematic diagram of the escape system.

A one-second lap belt delay and a zero-second parachute delay system is provided for improved low-altitude escape capability. This system makes use of a detachable zero-delay lanyard attached to the parachute arming knob. At low altitude the zero-delay lanyard is hooked to the parachute ripcord handle to actuate the parachute immediately after its separation from the seat. At other altitudes or at high airspeed the lanyard is disconnected to allow the parachute timer or aneroid device to actuate the parachute. The minimum escape altitudes for landing and take-off conditions are shown in Fig. 81.

F–106 MODIFIED UPWARD EJECTION SEAT
WITH DROGUE GUN DEPLOYED PARACHUTE
EVENTS CODE:
A. ROCKET THRUST BURNOUT
B. LAP BELT RELEASE SEAT-MAN SEPARATION
C. PILOT CHUTE OPEN
D. MAIN CANOPY DEPLOYMENT
E. FULL LINE STRETCH
F. CHUTE FULL BLOSSOM

TEST NUMBER	I	II	III
PERCENTILE	5	95	95
EJECT VEL	315 KN	89 KN	0-0
BURN TIME	0.404 SEC	0.[illegible]0 SEC	0.555 SEC

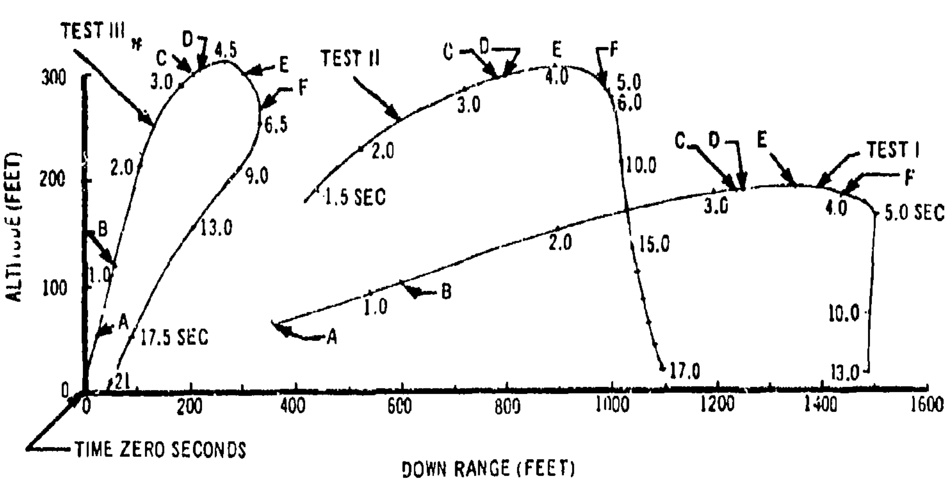


Figure 77. F-106 Modified Upward Ejection Seat with Drogue Gun Deployed Parachute – Ejection and Recovery Trajectories

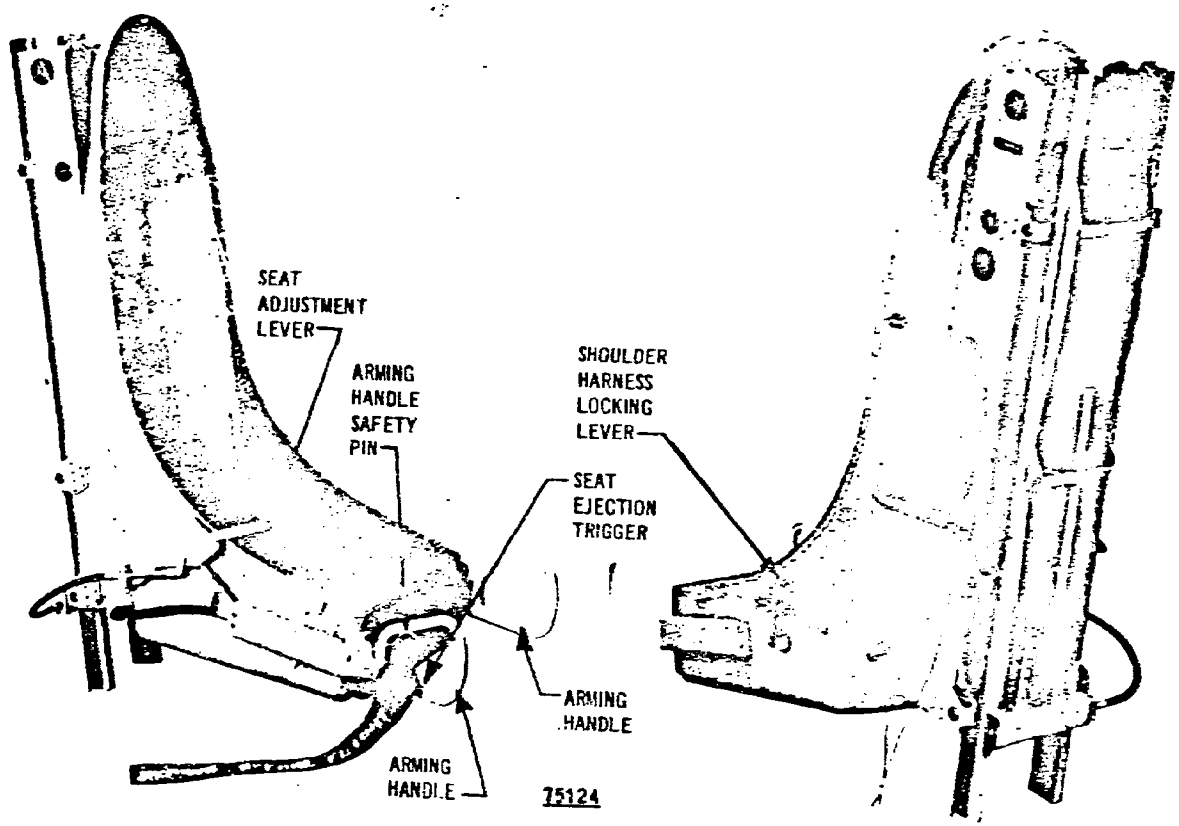


Figure 78. Weber Lightweight Ejection Seat for T-37 – General Arrangement

Table XIV gives the lightweight seat escape system weight breakdown.

Table XIV. T-37 Lightweight Seat Escape System Weight Breakdown

Item		Weight (Lb)
Seat		62.25
Basic structure	53.00	
Inertia reel and control	2.50	
Initiators	2.00	
Pilot service disconnect	1.25	
Ballistic disconnect	.50	
Lap belt harness	3.00	
Seat cushion		2.50
Parachute assembly		25.00
Ballistic catapult (M5)		17.00
Fixed guide rail assembly		14.00
Pilot (50 percentile)		176.00
Personal gear		10.00
Total Weight		306.75

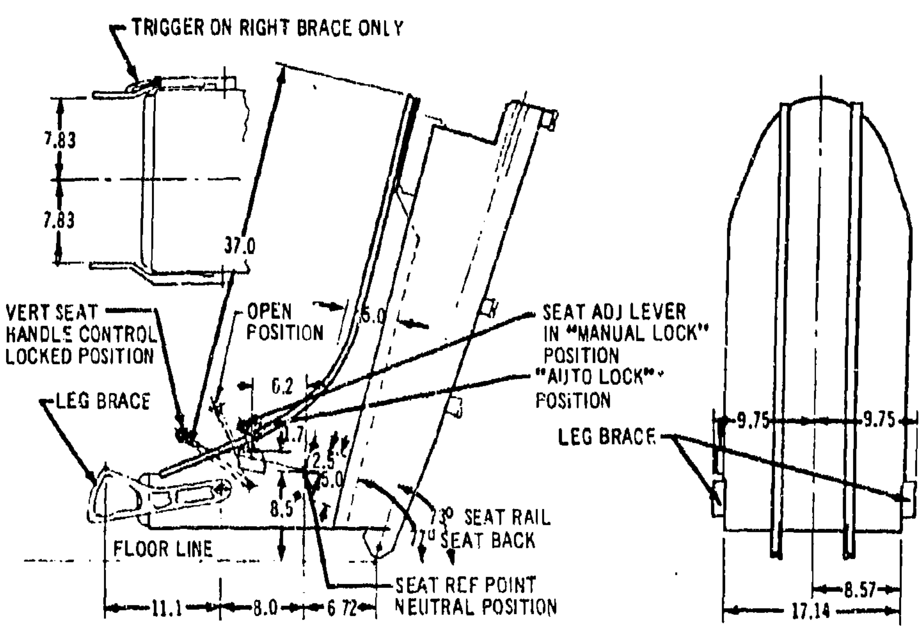


Figure 79. Weber Lightweight Ejection Seat for T-37 – Major Installation Dimensions

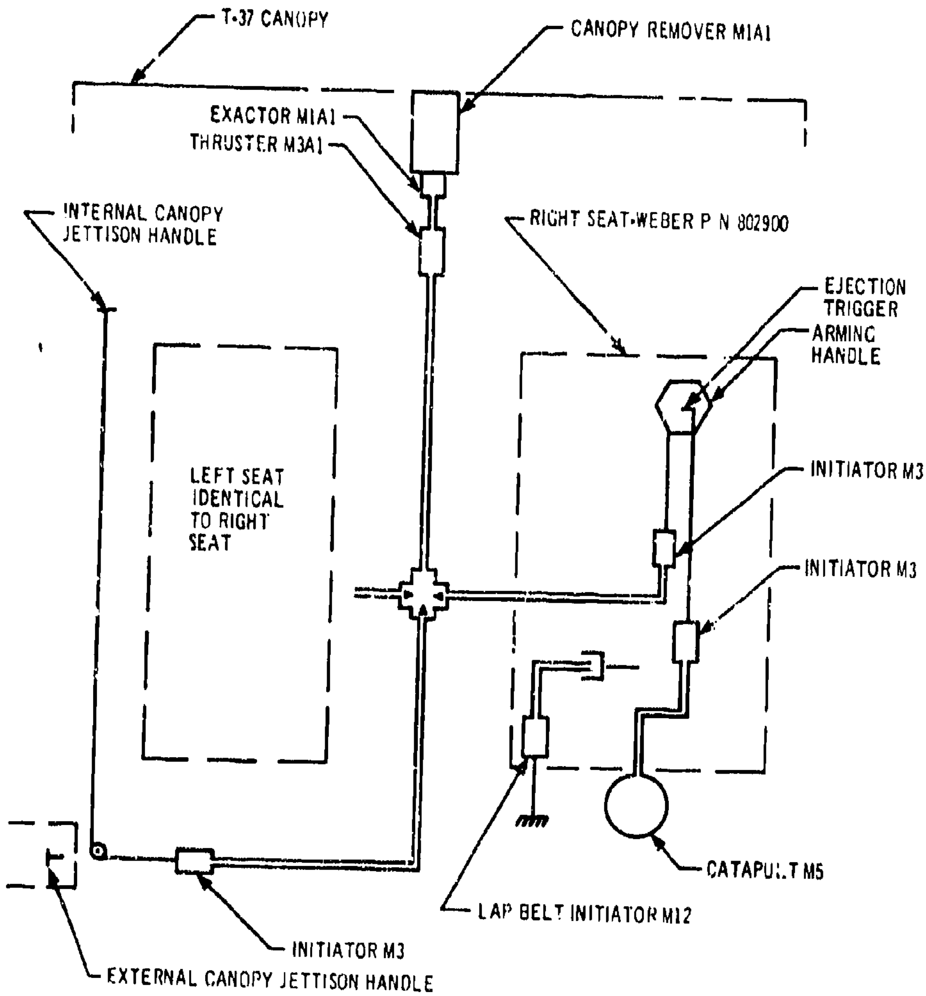
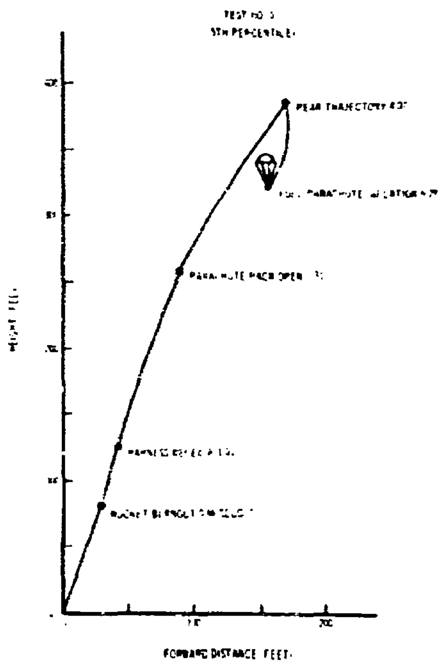


Figure 80. Schematic of Escape System – T-37 Airplane



	1 SECOND PARACHUTE	0 SECOND PARACHUTE
	F-1B TIMER	ZERO DELAY LANYARD TO PARACHUTE RIPCORD HANDLE
	BA-15 PACK / C-9 CANOPY	BA-15 PACK / C-9 CANOPY
1 SECOND AUTOMATIC SAFETY BELT (M12) INITIATOR	200	100

Figure 81. Emergency Minimum Ejection Altitudes -

n. WEBER GEMINI SEAT

The Gemini escape and survival system consists of an open ejection seat, ejection initiation system, escape hatch actuator system, rocket-catapult, egress kit, integrated harness release system, seat-man separator, ballute The system is designed to provide safe escape from the ground to 70,000 feet altitude, while the capsule is positioned on the launch pad during boost, and dur-
altitude, while the capsule is positioned on the launch pad during boost, and dur-
ing capsule re-entry conditions. While ejection capability is available throughout the mission, actual usage is determined by the altitude, type of emergency, system condition, mission phase, and the astronaut's evaluation of the problem. All subsystems and components were designed to function through an ambient temperature of -65° to 200°F. Figure 82 is a photograph of the seat and the overall installation dimensions are shown in Fig. 83.

Two ejection seats are arranged side-by-side facing the small end of the Gemini spacecraft crew compartment. The seats are identical with respect to mode of operation. Both systems are initiated by either the pilot or copilot pulling the ejection D-ring located on the front of an egress kit which he sits upon. After initiation, the systems are completely automatic. However, provisions are made for manual actuation of all subsystems that effect safe recovery of the astronaut.

Pulling either seat ejection D-ring results in mechanical and ballistic actuation of mechanism to automatically perform the following functions: open escape hatches; eject astronauts, seats, survival equipment; separate astronaut with survival equipment from seat; provide bail-out oxygen; stabilize astronaut in free fall; deploy recovery parachute, disconnect egress kit and backboard; and deploy survival kit. Below 5,700 ± 600 feet the time from initiation of the escape system to parachute deployment is approximately four seconds.

Pulling the D-ring fires an initiator, igniting the MDF (Mild Detonating Fuse) train, which ignites the propellant in the hatch actuators. Latch tripping plungers release the hatch locks, and as the plungers approach the end of their stroke, the gas is vented through a port to power the hatch actuator piston. The first few inches of the piston extension opens the hatches and locks them in the open position. Further extension of the piston allows the gas to be vented through a port to the RPI No. 2194-15 rocket-catapult. The initial catapult thrust propels the seat up the fixed rails, and after approximately 38 inches of travel, the rocket motor ignites and sustains thrust for about 0.28 seconds. The rocket-catapult thrust is sufficient to propel the ejected mass along the required trajectory and free of the capsule prior to astronaut-seat separation and parachute deployment.

Movement of the seat up the fixed rails exerts a pulling force on four lanyards which are attached to the capsule structure and components of the ejection seat. The lanyards cause the aeromed, audio, and oxygen leads to be separated from the capsule; the 15-minute (1,800 psi) emergency oxygen to be turned on; supplies a 3.5 psia pressure in the suit; and initiates the harness release actuator assembly.

Figure 82. Weber Gemini Seat

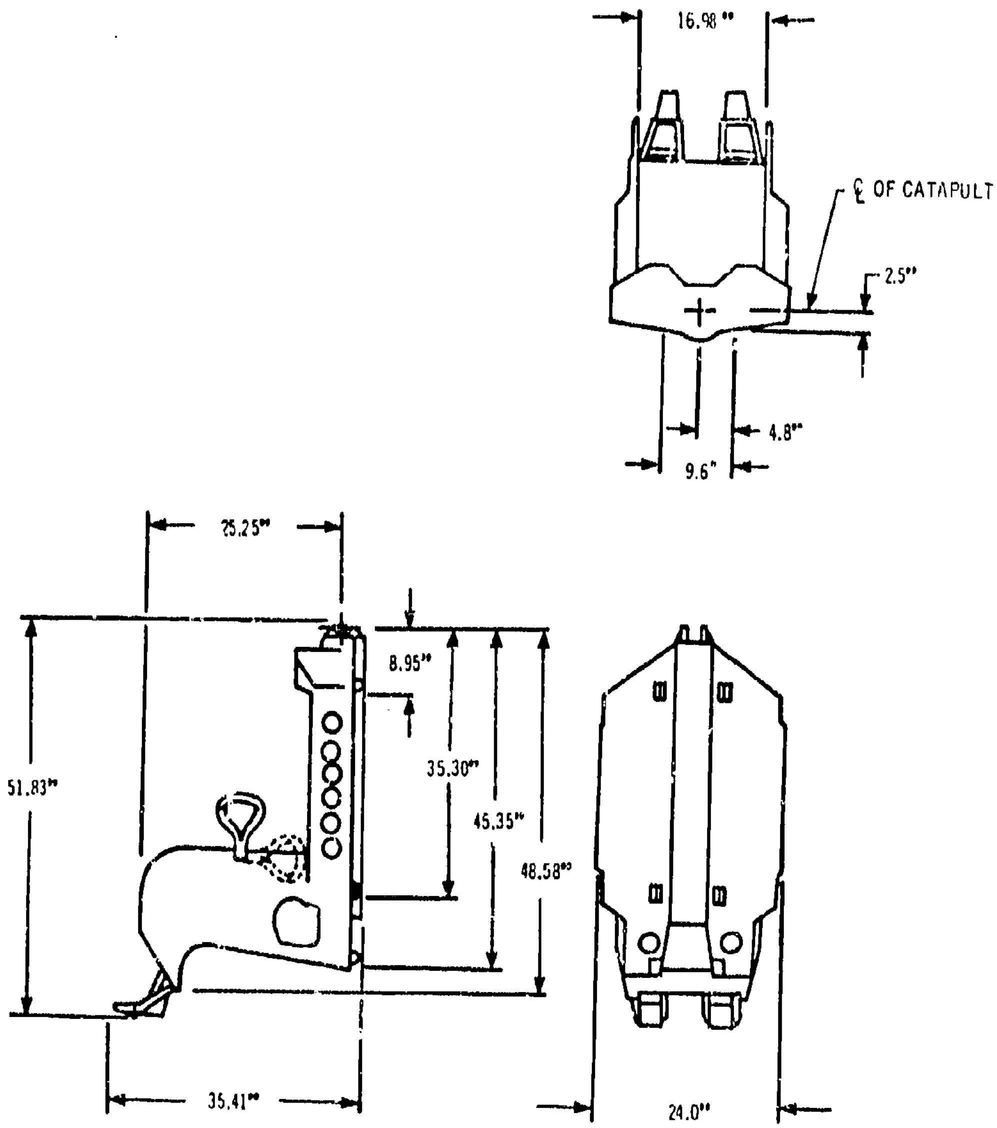


Figure 83. Weber Gemini Seat Installation Dimensions

The harness release actuator assembly has a one-second time delay cartridge allowing the astronaut-seat to attain the required distance along the trajectory before firing the thruster. As the WAC thruster piston extends, it pulls the seat-man separator strap assembly taut and forcibly separates the astronaut with the attached egress kit and backboard assembly from the seat. During separation, a pulling force is exerted on four lanyards; two of the lanyards initiate the aneroid mechanism of the ballute deploy and release assembly, another lanyard initiates the aneroid mechanism of the recovery parachute drogue mortar, and the fourth lanyard initiates the automatic signal of the radio beacon in the survival kit.

The aneroid mechanism in the ballute deploy and release assembly prevents deployment of the ballute if the emergency occurs below 7,500 ± 700 feet Above that altitude the aneroid mechanism fires a five-second delay cartridge which generates high-pressure gas to operate a guillotine to cut the ballute pad retaining cord and allow spring action to deploy the Goodyear four-foot diameter ballute. Dynamic pressure inflates the combination ballute and parachute which stabilizes the astronaut and prevents him from tumbling and/or going into a flat spin at high altitude. When the astronaut falls to 7,500 ± 700 feet, the aneroid mechanism fires another cartridge operating a guillotine to cut the ballute risers and release it from the backboard assembly, permitting the astronaut to free fall.

The aneroid mechanism in the drogue mortar permits firing only at altitudes below 5,700 ± 600 feet. The aneroid mechanism triggers a firing mechanism which ignites a 2.3 second delay cartridge supplying high-pressure gas to propel the drogue slug out of the mortar with sufficient velocity to forcibly open the parachute pack, deploy the attached 40-inch diameter pilot chute, and extract part of the C-9 canopy. Dynamic pressure inflates the pilot chute and the resultant drag fully extracts the main canopy. Inflation and drag of the main canopy provides a safe descent rate and recovery of the astronaut. Gas from the drogue mortar cartridge activates a five-second MDF time delay cartridge. The time delay allows adequate time for parachute deployment and astronaut-egress kit-backboard stabilization. The cartridge fires the MDF line running to the MDF manifold assembly where a cap is detonated that fires three high-explosive caps in the manifold. The caps initiate three MDF lines: one to the inertia reel strap cutter, one to the lap belt disconnect, and the other to the jetolox release pin. Action of the release mechanisms causes the backboard and egress kit to fall from the astronaut. When the backboard falls, it trails a 20-foot line which is attached to the astronaut's parachute harness. The life raft and rucksacks containing survival equipment are pulled from the two survival kit containers. Momentum of the two rucksacks triggers a CO_2 valve in the life raft, and the astronaut then descends with the survival equipment and the inflated life raft attached to him.

After a water landing is made, there are three modes of flotation survival existing in the system as follows:

- Water wings attached to the harness which the pilot can inflate.
- Life raft in the survival kit (primary).

- Space suit may be used to float the astronaut after it is sealed from water leakage by a rubber collar which is stored in a pocket on the space suit.

An extensive test program was accomplished on the Gemini escape system. The complete system was fired under the conditions as shown in Table XV. There were a total of 25 ejection tests consisting of 7 sled ejections at various speeds, 15 simulated off-the-pad ejections, and 3 ejections from the F-106 at various airspeeds and altitudes. The test program was devised to test the complete system under various simulated emergency conditions throughout the designed performance envelope. Typical performance trajectories with the event-time sequence are shown in Figs. 84 and 85. The seat performance capability during the boost and re-entry phase is shown in Fig. 86.

Table XV. Weber Gemini Seat – Ejection Tests

TEST	DATE	SINGLE	DUAL	SPEED (FPS)	ALTITUDE (FT)
SOPE 1	7-2-62	X		0	150
SOPE 2	7-17-62	X		0	150
SOPE 3	7-25-62	X		0	150
SOPE 4	7-26-62	X		0	150
SOPE 5	8-3-62	X		0	150
SOPE 6	9-12-62	X		0	150
SOPE 7	9-26-62		X	0	150
SOPE 8	2-7-63		X	0	150
SOPE 9	5-17-63	X		0	150
SOPE 9A	5-25-63	X		0	150
SET 2	6-19-63		X	893	GROUND LEVEL
SOPE 10	7-2-63		X	0	150
SOPE 11	7-16-63		X	0	150
SET 3A	8-9-63		X	848	GROUND LEVEL
SET 4	1-16-64		X	367	GROUND LEVEL
SET 5	2-7-64		X	910	GROUND LEVEL
SET 7	7-1-64		X	400	GROUND LEVEL
HAET 1	10-15-64	X		0	GROUND LEVEL
SET 8	11-5-64		X	943	GROUND LEVEL
SET 9	12-11-64		X	872	GROUND LEVEL
SOPE 12	1-16-65		X	0	150
HAET 2	1-28-65	X		693	15,700

Table XV. Weber Gemini Seat – Ejection Tests (Cont)

TEST	DATE	SINGLE	DUAL	SPEED (FPS)	ALTITUDE (FT)
SOPE 13	2-12-65		X	0	150
HAET 3	2-12-65	X		1.72 M	40,000
SOPE 14	3-6-65		X	0	150

SOPE = SIMULATED OFF PAD EJECTION (NOTS TOWER)
SET = SLED EJECTION TEST (SNORT - NOTS)
HAET = HIGH ALTITUDE EJECTION TEST (EL CENTRO F-106)

The accelerations imposed on the dummy occupants during the tests were measured to be approximately 12 g average, with a peak of 20 g during the catapult stroke. The accelerations measured during rocket burning were, in all tests, of a lower magnitude. Performance of the escape system during the test program was successful, and it was accepted as operational Gemini equipment.

Table XVI gives the seat weight breakdown.

Table XVI. Weber Gemini Seat Weight Breakdown

	Weight (Lb)
Ejectable	
Seat structure	54.90
Integrated harness release system	7.10
Seat/Man separator	3.40
Backboard and survival gear	18.80
Egress kit assembly (including oxygen)	20.25
Egress kit cushion, back cushion, and pelvic block	5.53
Lap belt and strap assembly	4.23
Parachute assembly	17.55
Ballute assembly	8.00
Survival system	22.05
RPI 2194 rocket-catapult	23.00
	184.81
Nonejectable	
Track assembly	30.5
Rocket-catapult shell 2194	5.5
	36.0
Total Weight	220.81

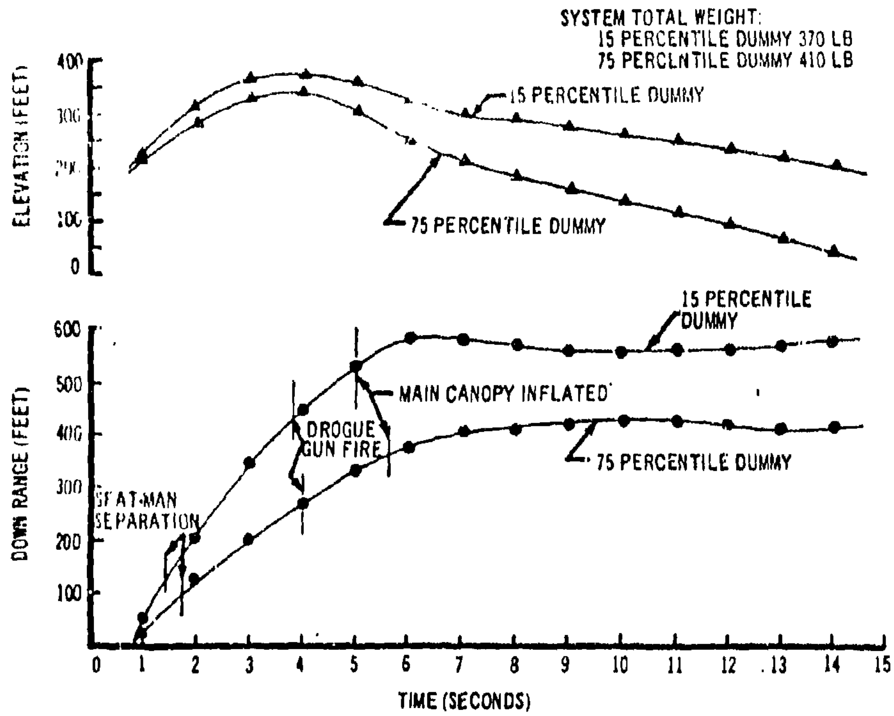


Figure 84. Weber Gemini Escape System Test Trajectories Simulated Off Pad Ejection

15 PERCENTILE DUMMY TOTAL SYSTEM WEIGHT 370 LB
SLED VELOCITY 520 KEAS

75 PERCENTILE DUMMY TOTAL SYSTEM WEIGHT 408 LB
SLED VELOCITY 210 KEAS

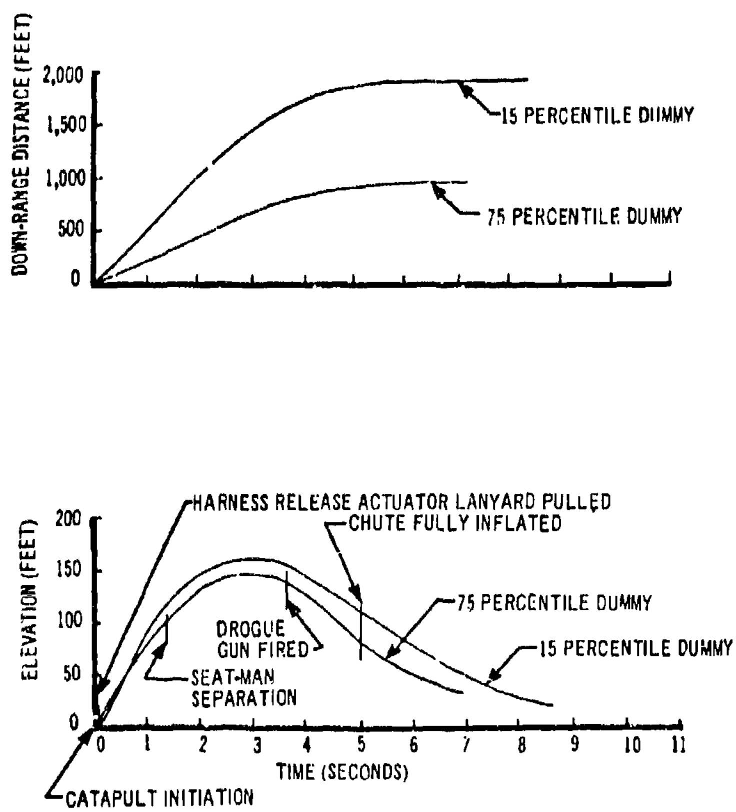


Figure 85. Weber Gemini Escape System Test Trajectories – Various Sled Velocities

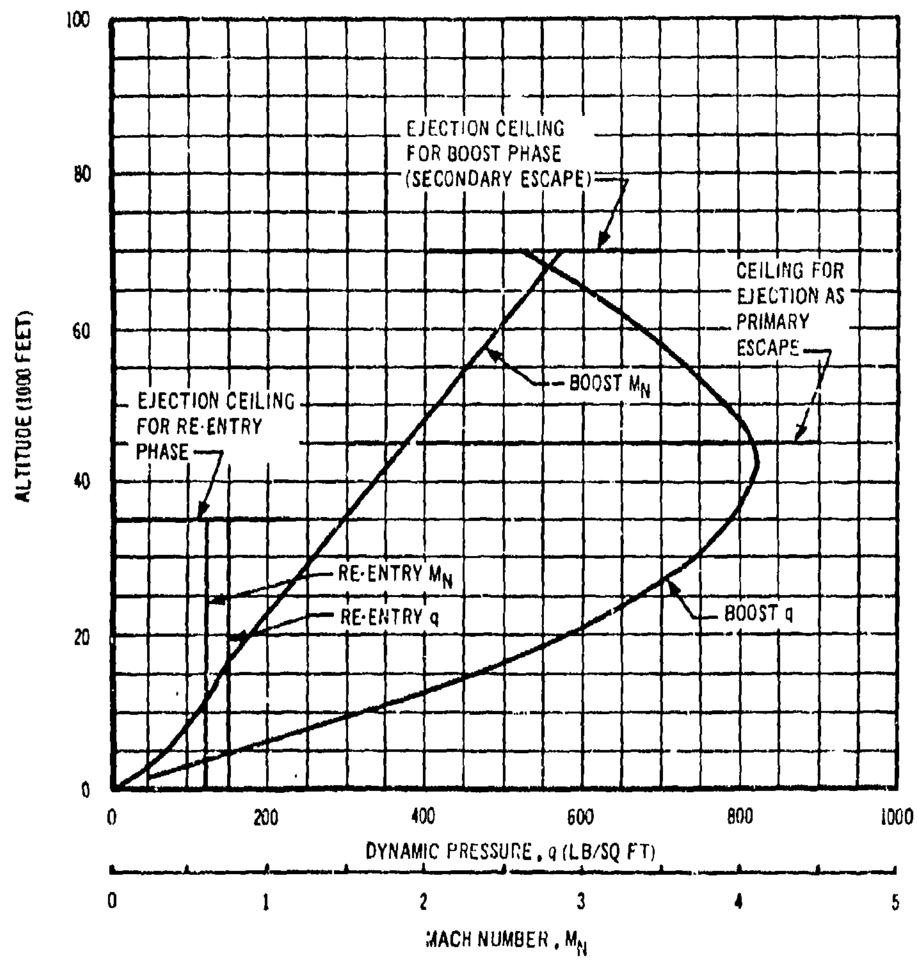


Figure 86. Weber Gemini Escape System Seat Performance Capability

o. WEBER DYNA-SOAR SEAT

The Dyna-Soar escape system consists of an open ejection seat, seat adjustment mechanisms, rocket-catapult, powered inertia reel, body restraint system, leg and arm supports, seat-man separator, parachute system and survival kit. A photograph of the system is shown in Fig. 87 and the overall installation dimensions are shown in Fig. 88.

Ejection sequence is initiated by actuating a two-handed ejection control located on the front edge of the seat bucket and extending upward between the pilot's legs. A schematic of the ejection and timing sequence is shown in Fig. 89. When the ejection control is pulled toward the pilot the seat recline snubber is unlocked and the inertia reel initiator is fired. The hatch is jettisoned, removing the safety pin and allowing the catapult initiator to be mechanically fired. Gas from the inertia reel cartridge operates the reel and forcibly pulls the pilot back into the confines of the movable seat back and the seat back to the full aft position. Acceleration of the seat back is controlled by the seat back snubber as it is moved to the ejection position. After the pilot and seat are properly positioned, the rocket-catapult fires and propels the seat up the fixed rails. As the seat moves up the rails the arm guards are rotated inward, the chaff dispenser is opened, and the 0.75-second delay integrated harness release initiator is fired. When the harness release is opened, the seat-man separator initiator is fired and, as the man separates from the seat, the automatic parachute timer is actuated. The recovery parachute is deployed at or below 14,000 feet altitude after a one-second delay.

Table XVII gives the seat weight breakdown.

Table XVII. Weber Dyna-Soar Seat Weight Breakdown

	Weight (Lb)
Ejectable	
Seat structure	65.5
Parachute pack (B-5 with C-9 canopy)	22.3
Survival kit and equipment	40.0
Pivoted seat back	11.7
Frankford arsenal XM10E1 rocket-catapult	21.1
Pressure suit fittings and emergency oxygen	31.0
	191.6
Nonejectable	
Fixed rail assembly	19.8
Rocket-catapult shell and bracket	4.7
	24.5
Total Weight	216.1

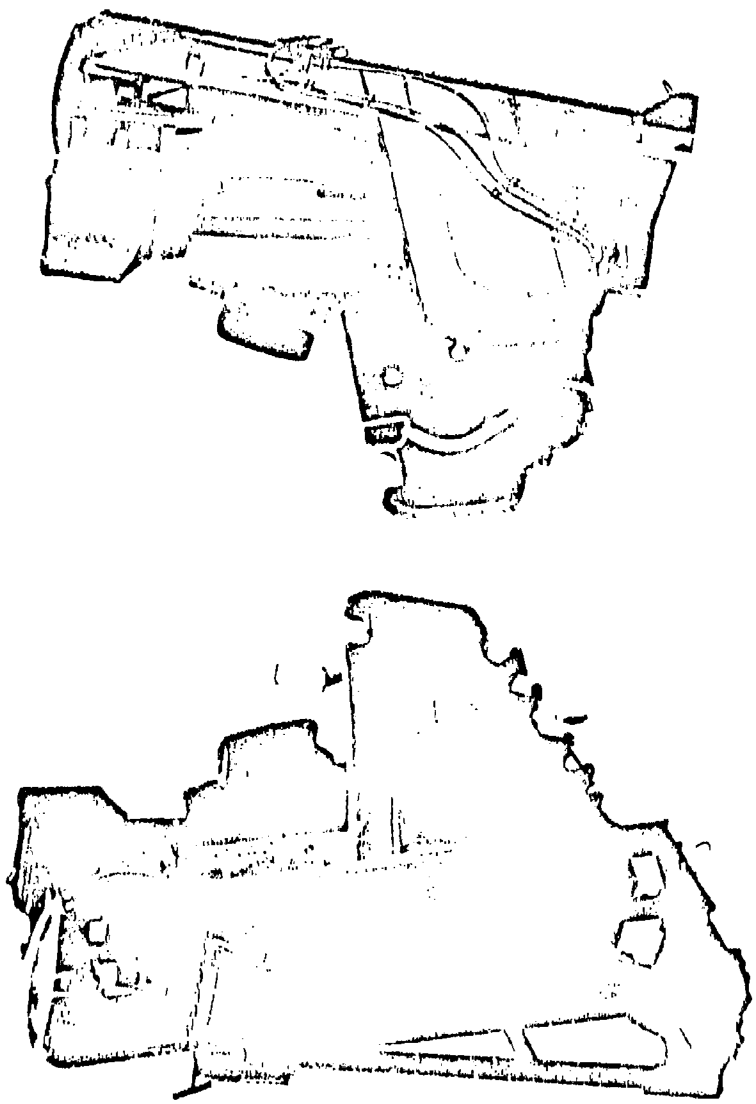


Figure 87. Weber Dyna-Soar Seat

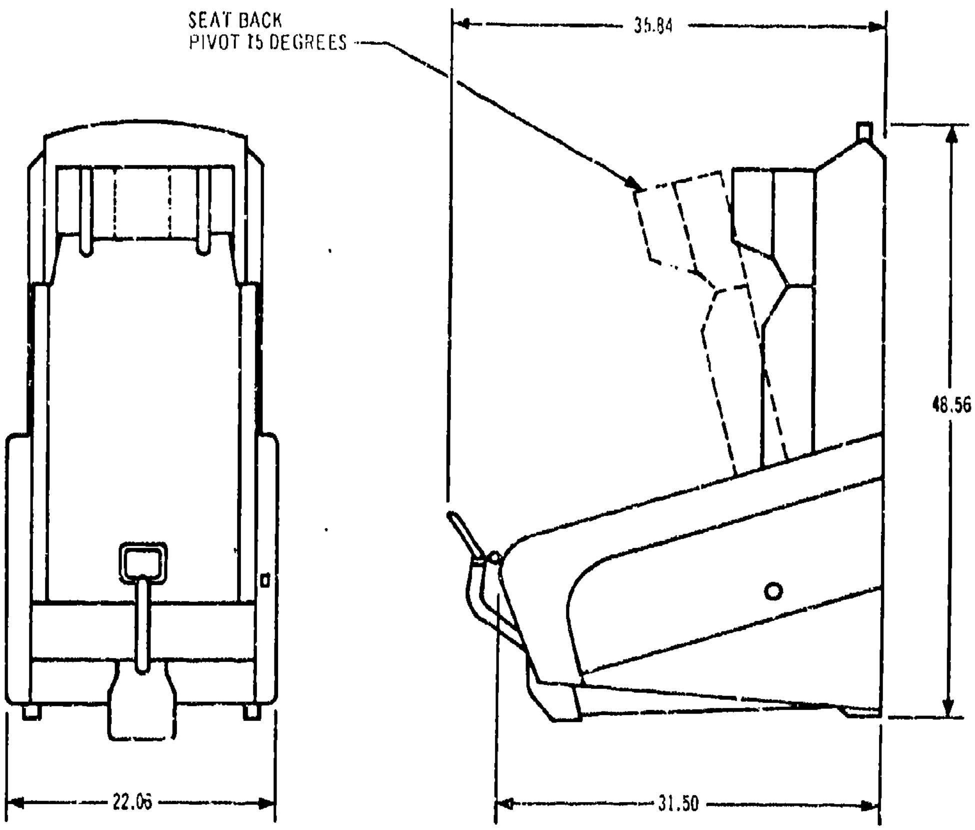


Figure 88. Weber Dyna-Soar Seat – Installation Dimensions

Performance analysis of the system was conducted utilizing the Weber Aircraft Analog Computer Facility. The calculations indicated the system would provide safe escape from zero-speed to 515 knots (900 psf) at sea level and at Mach 0.8 at 50,000 feet altitude. The analysis also indicated the acceleration loads imposed on the pilot were well within human tolerance limits when escape was initiated during simulated conditions within the Dyna-Soar performance envelope.

p. WEBER LUNAR LANDING RE. .ARCH VEHICLE SEAT

The LLRV escape system is comprised of an open ejection seat, pilot restraint system (without inertia reel), rocket-catapult, seat-man separator, and drogue gun deployed parachute system. The seat is shown in Fig. 90 and the overall installation dimensions are shown in Fig. 91.

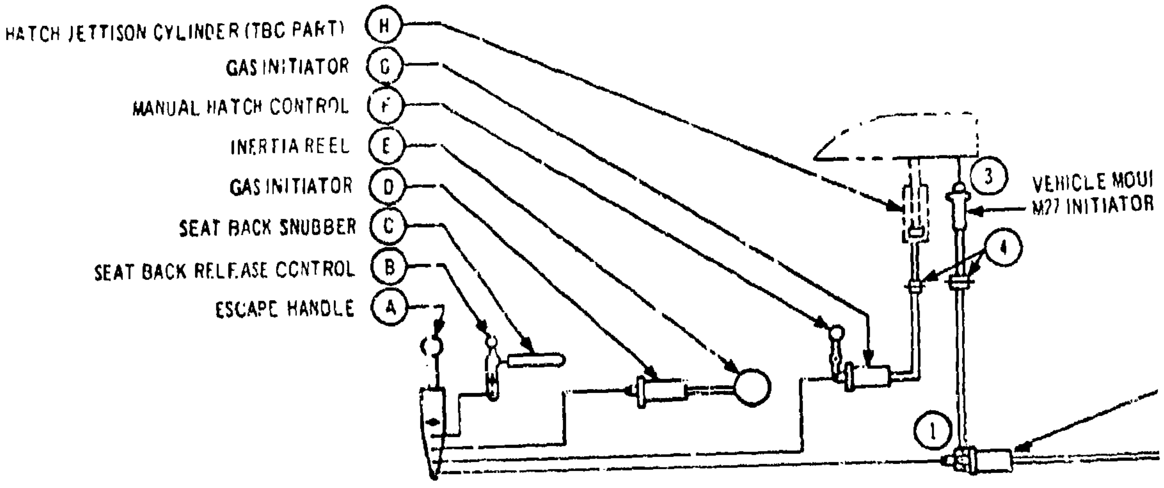
Escape system initiation is accomplished by pulling upward on a D-ring handle mounted on the front of the seat bucket to mechanically fire the catapult initiator. Initial movement of the seat up the fixed rails fires a one-second delay initiator to release the pilot three-point restraint system and fire the seat-man separator. The rocket motor is ignited as the seat leaves the fixed rails and continues to supply thrust for approximately 0.25 seconds.

As the restraint system releases are opened a one-second delay drogue gun initiator in the personnel parachute pack is fired. The drogue gun fires at approximately peak trajectory and deploys the 28-foot flat circular parachute.

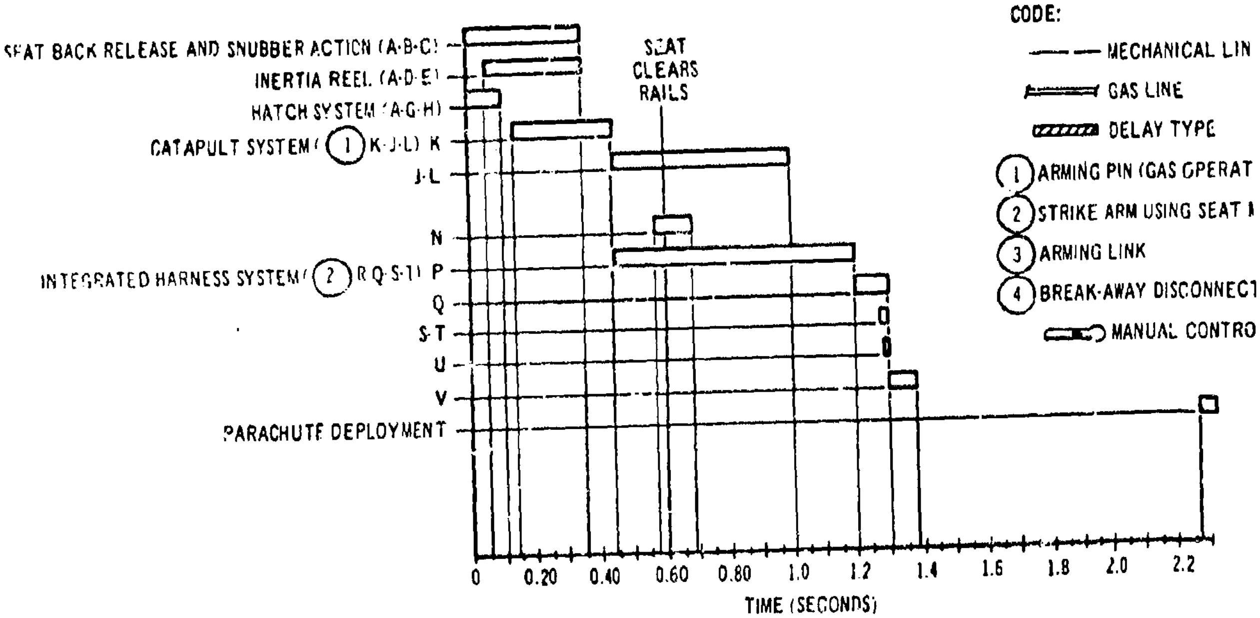
Emergency ground egress or "over the side bailout" is accomplished by pulling upward on the ditching handle located on the right side of the seat bucket. Movement of the ditching handle releases lap belt and shoulder restraints and disconnects the parachute lanyard to permit exit of the pilot with parachute from the seat. The parachute must now be deployed in the normal manner by the manual rip cord which overrides the automatic drogue powered system.

Survival equipment, emergency oxygen, flotation system, and stabilization devices are not provided in the escape system. Stabilization of the seat-man was attempted by keeping the rocket thrust line near the center of gravity.

The seat has been tested in various attitudes of roll, yaw and pitch from the static position. These tests were conducted by the Weber Aircraft Test Laboratory and the system performances were satisfactory, meeting the requirements of the NASA specification. During the three tests conducted, the static eccentricity of the rocket thrust line varied from 1.70 to 1.85 inches below the CG while the rocket thrust line was 49 degrees 35 minutes forward of the rocket centerline. The test sequence timing of events are given in Tables XVIII, XIX and XX for various seat attitudes from the static position. Table XXI gives the seat weight breakdown.



EVENT SEQUENCE



TIMING SEQUENCE

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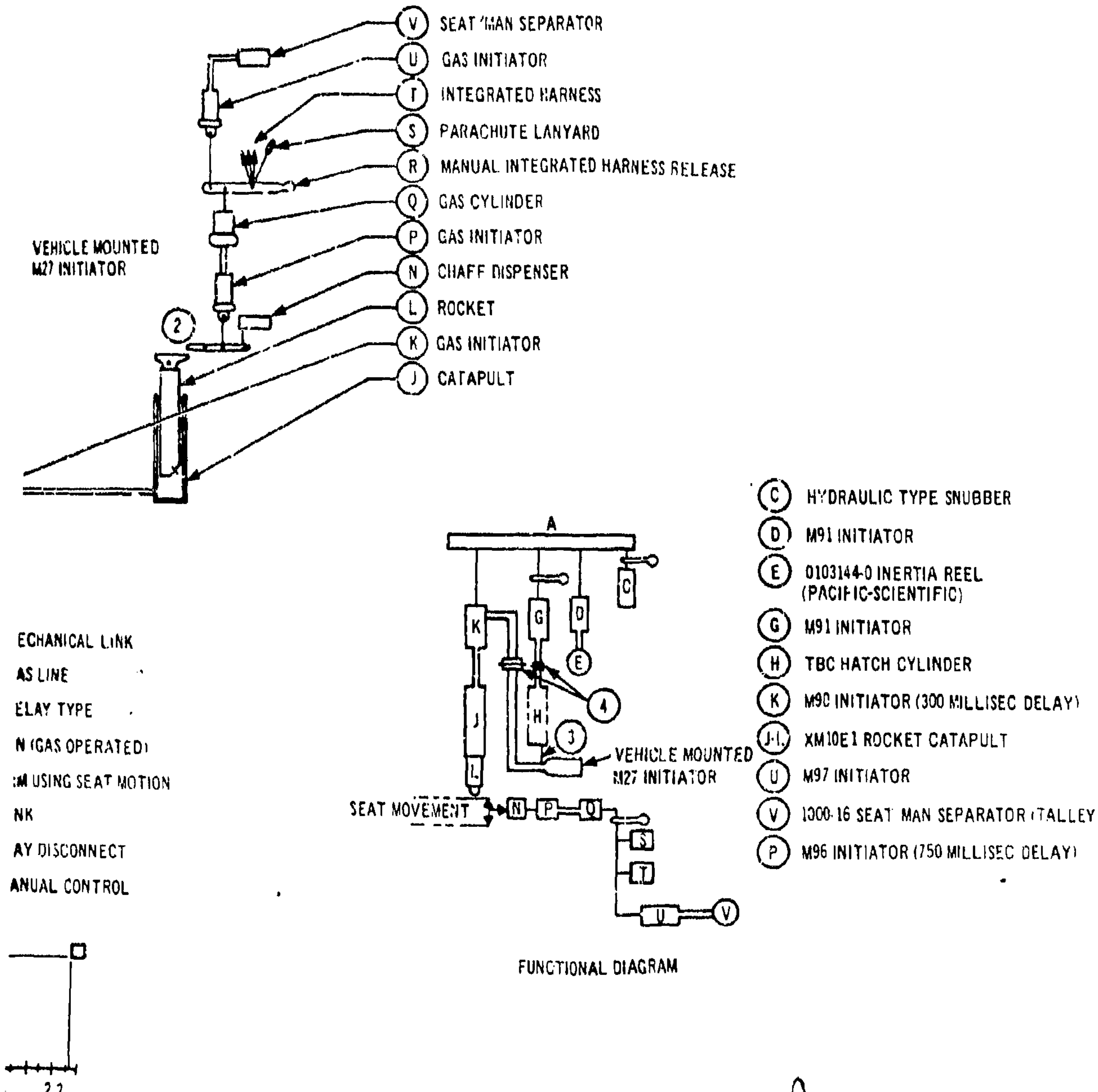


FUNCTIONAL DIAGRAM

EJECTION SEQUENCE

Figure 89. Weber Dyno-Soar Seat – Ejection Sequence

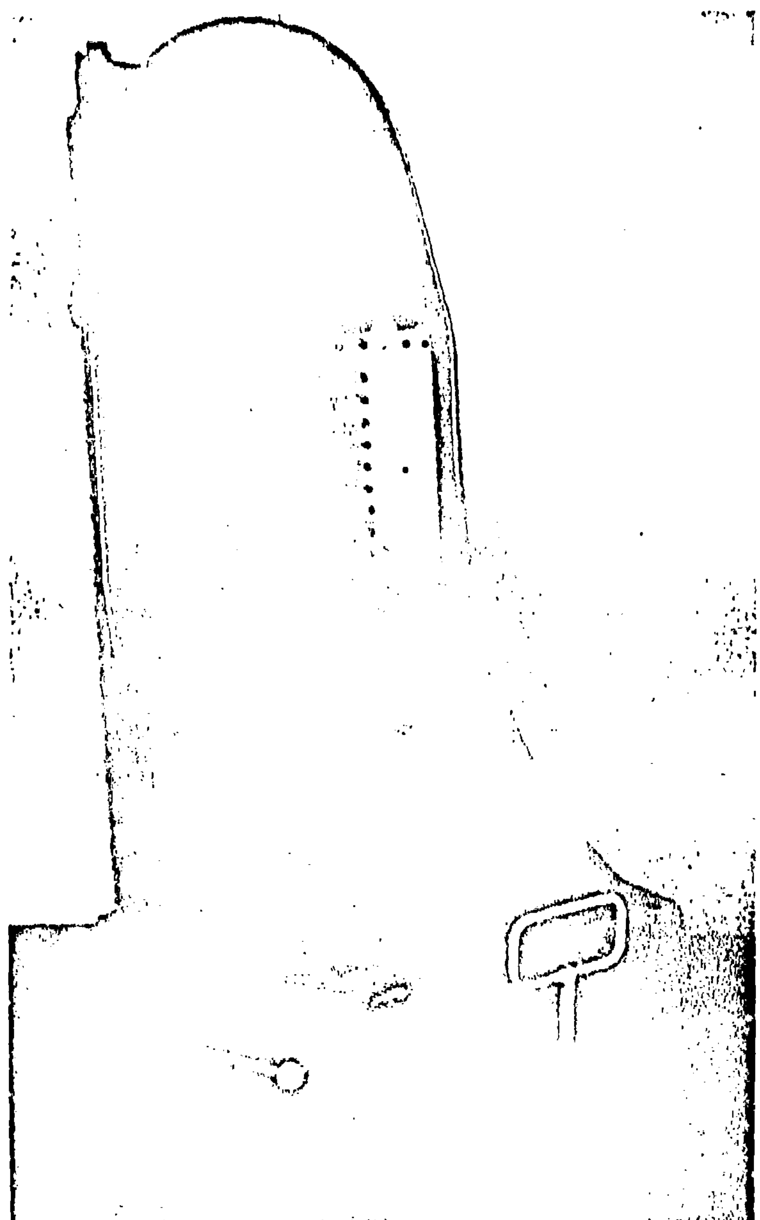


Figure 90. Weber (LLRV) Seat

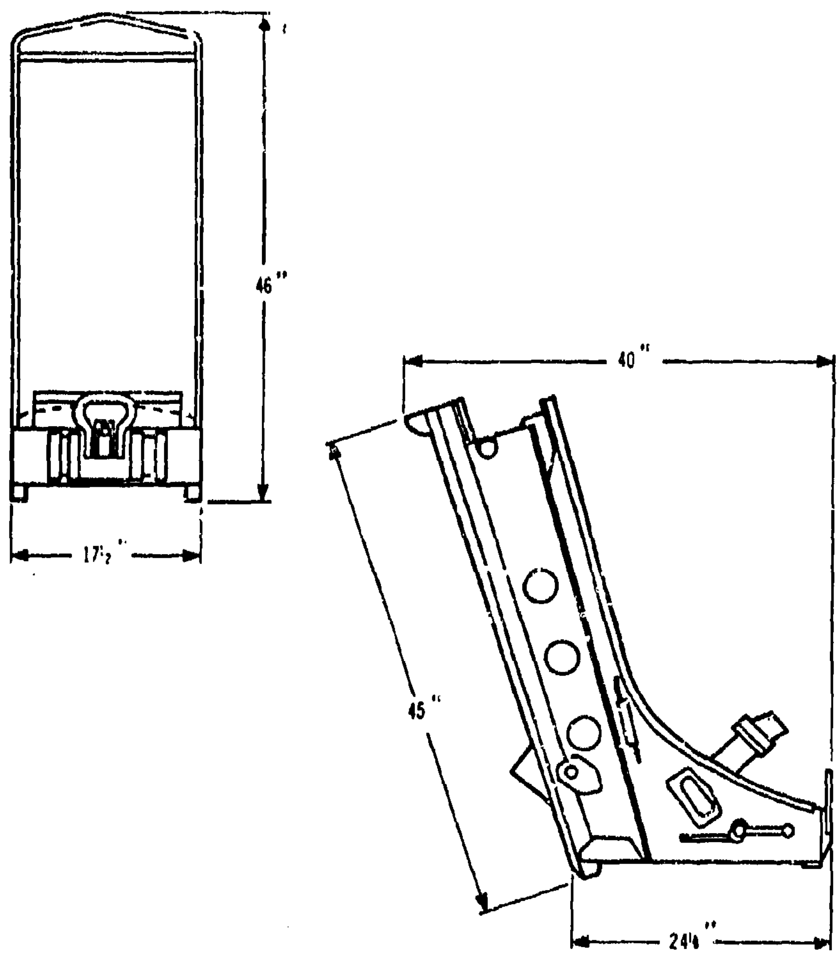


Figure 91. Weber (LLRV) Seat – Installation Dimensions

Table XVIII. Weber (LLRV) Escape System Timing

Seat in Normal Upright Position, Zero-Zero Condition
Total Ejectable Weight 294.8 lb, Dummy's Weight 182 lb

Time (Sec)	Elev. (Ft)	Event
0.0	0	Firing switch is pulled and rocket-catapult launch launch stage fires
0.563	34	Rocket burnout
1.069	80	Start of seat/man separation cycle
1.337	106	Seat/man separation
2.120	152	Drogue gun fires personnel chute
3.037	181	Peak trajectory
6.100	96	Dummy's parachute fully inflated

Table XIX. Weber (LLRV) Escape System Timing

Seat Rolled 30° to the Right from Vertical Attitude Zero-Zero Condition
Total Ejectable Weight 278.6 lb, Dummy's Weight 172.5 lb

Time (Sec)	Elev (Ft)	Event
0.0	0	Firing switch is pulled and rocket-catapult launch stage fires
0.567	36	Rocket burnout
0.858	60	Start of seat/man separation cycle
1.072	84	Seat/man separation
1.992	148	Drogue gun fires personnel chute
3.372	187	Peak trajectory
6.012	106	Dummy's parachute fully inflated

Table XX. Weber (LLRV) Escape System Timing

Seat Pitched 30° Forward from Vertical Zero-Zero Condition
Total Ejectable Weight 268 lb, Dummy's Weight, 178 lb

Time (Sec)	Elev. (Ft)	Event
0.0	0	Firing switch is pulled and rocket-catapult launch stage fires
0.835	35	Rocket burnout
1.102	47	Start of seat/man separation cycle
1.500	60	Seat/man separation
2.220	71	Drogue gun fires personnel chute
2.300	72	Peak trajectory
*	17	Dummy's parachute fully inflated

*No data recorded.

Table XXI. Weber (LLRV) Seat Weight Breakdown

	Installed Weight (Lb)	Ejectable Weight (Lb)	Nonejectable Weight (Lb)
Seat assembly	35.0	35.0	
Delay initiator	1.06	1.06	
Seat-man separator	3.26	3.25	
Lap belts	2.00	2.00	
Cushion	2.25	2.25	
Fixed rail	10.72		10.72
Catapult initiator	0.35		0.35
Rocket-catapult	18.25		
Parachute assembly	24.75	24.75	
Catapult housing			3.25
Pilot assembly (75 percentile)		176.00	
Clothes and harness		10.00	
Rocket (1/2 burned)		9.50	
Total Weight	97.63	263.81	14.32

Note: These are actual weights

q. B-52 UPWARD EJECTION SEAT

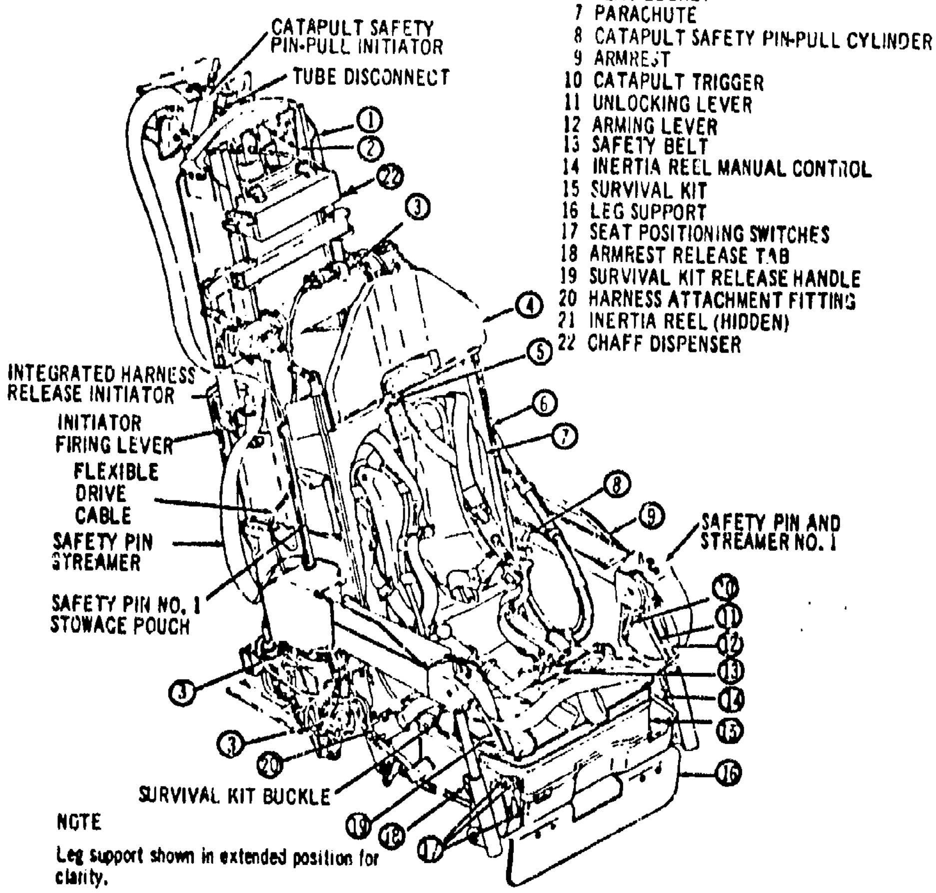
The B-52 airplane upward ejection seat escape system has undergone various improvements by production changes and retrofits. Some of these improvements were incorporated as a result of the airplane mission being redefined to include low-level flight. This description of the B-52 airplane upward ejection seat escape system is based on the latest system configuration.

A Weber-built, conventional ballistic catapult-powered, open-type upward ejection seat, and an automatically jettisoned overhead escape hatch is provided for each of the four crew members on the upper deck (pilot, copilot, EW officer, and gunner). There are no system interconnections between stations. The pilot and copilot ride and eject facing forward, and the EW officer and gunner ride and eject facing aft. Figure 92 shows the seat, Fig. 93 identifies the components, Fig. 94 shows the system schematic, Fig. 95. shows the seat envelope, and Table XXII shows the weight breakdown.

Table XXII. B-52 Upward Ejection Seat Weight Breakdown

		Weight (Pounds)
Nonejectable		33
Fixed rails	28	
Ballistic items	2	
Miscellaneous hardware	3	
Ejectable		119
Seat bucket with inertial reel	90	
Catapult	25	
Ballistic items	2	
Harness	2	
Man and Equipment		251
Fifty percentile man	167	
Clothing	10	
Survival kit	47	
Parachute	27	
Total Weight (Ejected)		370
Total Weight		403

Figure 92. B-52 Upward Ejection Seat



NOTE

Leg support shown in extended position for clarity.

Pilot seat shown; copilot, EW officer, and gunner seats similar except as noted.

Figure 93. B-52 Upward Ejection Seat

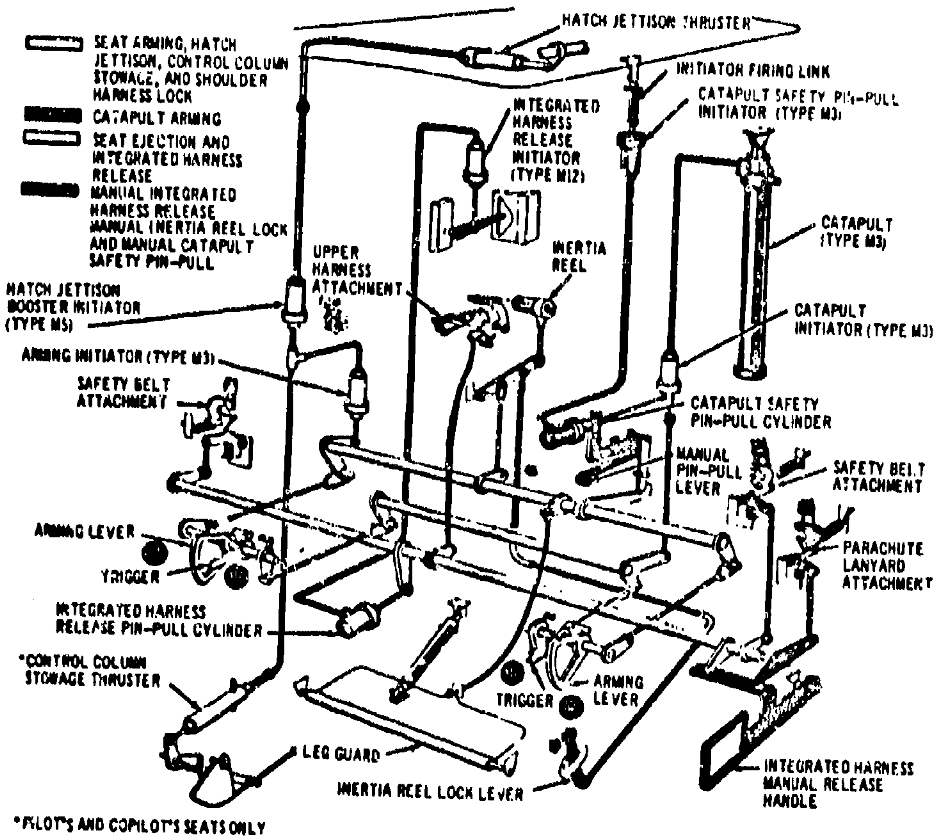


Figure 94. B-52 Upward Ejection Seat Schematic

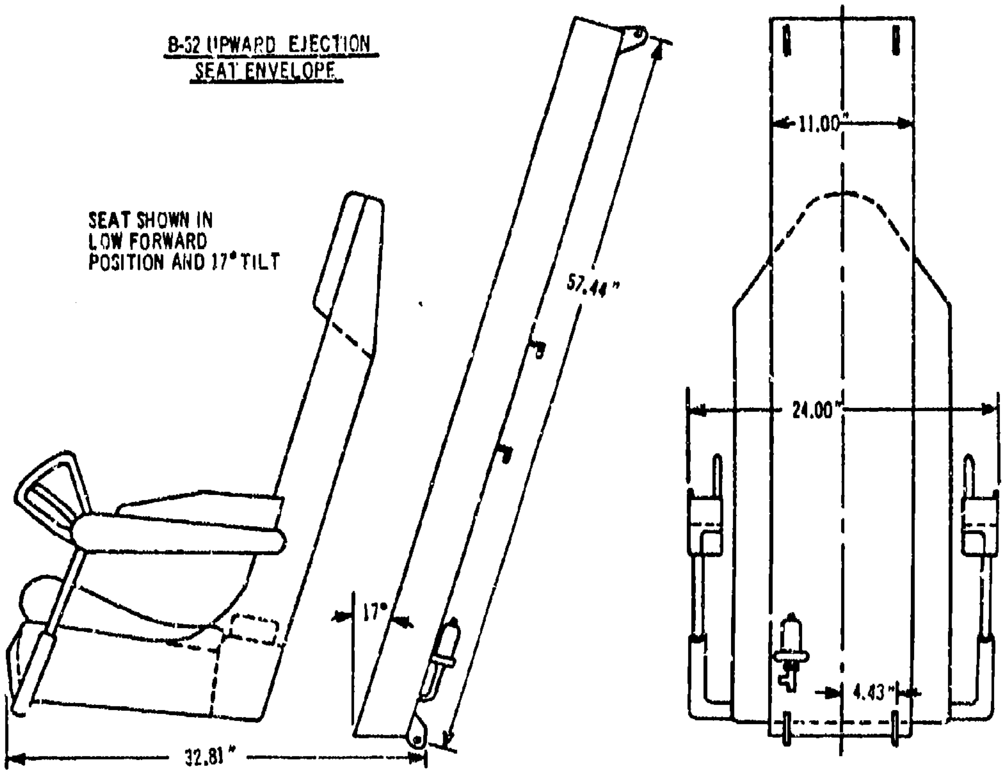


Figure 95. B-52 Upward Ejection Se·t Envelope

Each seat consists of a seat bucket, three electrical seat bucket positioning actuators, jettisonable rails, fixed rails, and chaff dispenser. The seat bucket is equipped with a spring-powered inertia reel, stowable armrests, headrest, ejection controls, leg support plate, and lap belt, and contains a global survival kit and personnel parachute. The jettisonable rails are roller-mounted to the fixed rails, which are installed 13 degrees from vertical for aft-facing seats and 17 degrees from vertical for forward-facing seats. The seat bucket is anchored to the jettisonable rails through three positioning actuators. The horizontal positioning actuator provides a maximum of 2.80 inches travel, the vertical positioning actuator provides a maximum of 5.60 inches travel, and the tilt actuator provides a maximum of plus or minus 4.75 degrees adjustment from rail angle. The actuators are independently operable, but one set of jackscrews on the tilt actuator is cable-driven from the horizontal positioning actuator to eliminate seat bucket tilt during horizontal adjustment.

The crewmember sits on the global survival kit located in the seat bucket and is strapped to the survival kit and to his parachute. He is secured to the seat by his parachute harness and a nonautomatic lap belt. The parachute harness shoulder straps attach to the inertia reel through a release fitting on the harness tabs. The belt is attached to the seat by releasable hooks. The seat armrests may be stowed for crew comfort or for facilitating crew movement. The parachute has two lanyards for controlling deployment. One lanyard runs from the aneroid timer in the parachute pack to the lanyard attachment point on the left hand side of the seat bucket as shown on Fig. 94, and remains connected throughout the flight. This lanyard actuates a one-second delay from seat-man separation before parachute deployment at altitudes below 14,000 feet (the aneroid feature prevents parachute deployment at higher altitudes). The second lanyard branches from the first and has a snap hook for attachment to the parachute manual deployment handle as shown in Fig. 93. This low-level lanyard, when connected, pulls the parachute rip cord during seat-man separation.

Ejection is accomplished by lifting both armrests to the unstowed position (if they aren't already up), rotating either or both arming levers up, and squeezing the trigger in either arming lever. Rotation of either arming lever locks the inertia reel, extends the leg guard plate, stows the control column (on pilot and copilot seats), and jettisons the hatch. Hatch jettison fires an initiator that provides the gas pressure for automatic catapult safety pin retraction. (The catapult safety pin has a handle for manual pin retraction also.) Squeezing the trigger fires the catapult, and as the seat moves up the rails the one-second delay, integrated harness release initiator is fired. This initiator provides the energy to release the restraining harness from the seat, and permits the seat and occupant to separate. Man-seat separation actuates the parachute pack deployment system. The parachute is deployed by a spring-loaded pilot chute that pulls the recovery parachute from the pack. After the parachute is inflated, the crewmember may pull a handle on his survival kit to cause it to fall below him, where it is suspended from his parachute harness; the life raft then is inflated.

Performance of the B-52 upward ejection seats has been demonstrated by sled tests conducted at speeds from 191 to 444 KEAS. Digital computer extrapolation of test data resulted in predicting full recovery during ground level ejections at airspeeds from 120 to 400 KIAS with the low-level parachute deployment lanyard connected. Without the low-level parachute deployment lanyard connected, at least 125 feet altitude above ground is required for full recovery. Figure 96 shows the flight conditions for which low-level lanyard is, and is not, recommended. Figures 97 and 98 show computer predicted trajectories.

The sled tests revealed that the B-52 upward ejection seats tumble in flight, primarily because the catapult stroke length exceeds the guided rail length, thus imparting a rotational velocity to the seat. The tumbling facilitates seat-man separation. Also, the sled tests showed that spinal acceleration during catapult stroke was less than 20 g. Seat pitch rates and dummy spinal accelerations recorded during 193 and 437 knots equivalent airspeed tests are shown in Fig. 99.

2. ENCAPSULATED SEATS

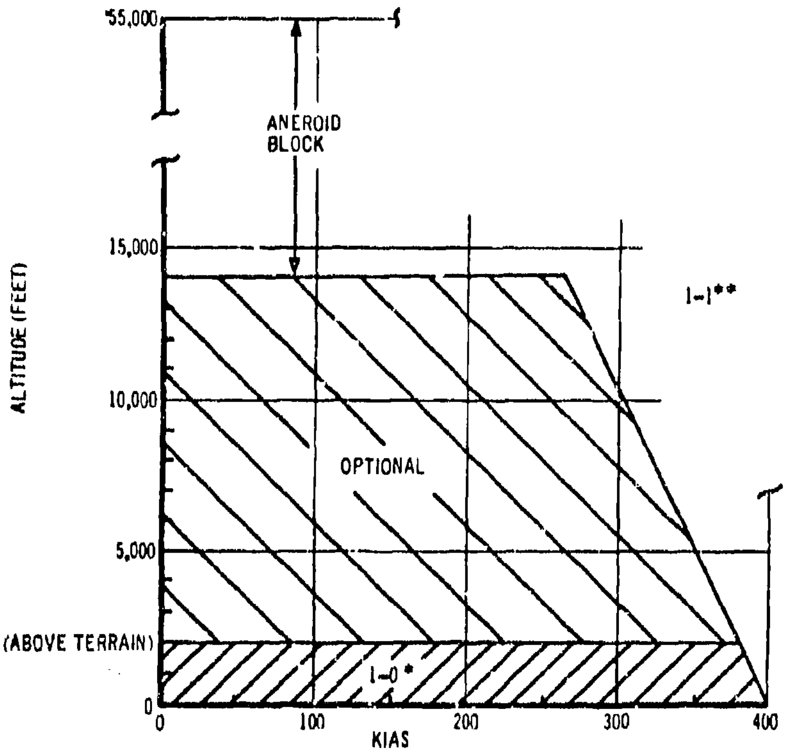
a. GOODYEAR ENCAPSULATED SEAT

The Goodyear encapsulated seat resulted from a research and development program conducted under an Air Force contract for the investigation of escape capsule systems for a hypothetical multiplace aircraft. This program covered the preliminary design and dynamic model and wind tunnel model testing of an individual escape capsule. A report of the program is presented in Ref. 4.

The Goodyear encapsulated seat escape system is designed to provide safe escape over an aircraft performance envelope having a maximum equivalent airspeed of 800 knots through an altitude range from sea level to 55,000 feet, and at Mach 4.0 from 55,000 to 100,000 feet with a flight duration of 30 hours. The capsule will provide safe escape at a 150 knot speed under landing or takeoff. The system design performance capability is shown in Fig. 100. The general arrangement of the capsule is shown in Fig. 101.

A schematic of the pre-ejection and ejection sequence is shown in Fig. 102. If an inflight emergency develops, lifting either handgrip initiates crew restraint, closing of capsule doors, and pressurization of capsule. Abandonment of the aircraft is accomplished by squeezing either or both of the ejection triggers. Three ballistic subsystems make up the complete automatic sequence with two manually operated ballistic subsystems supplementing the automatic system. These subsystems are the pre-ejection system, emergency ejection system, ballistic recovery system, manually operated water and ground landing functions, and manually operated door opening system.

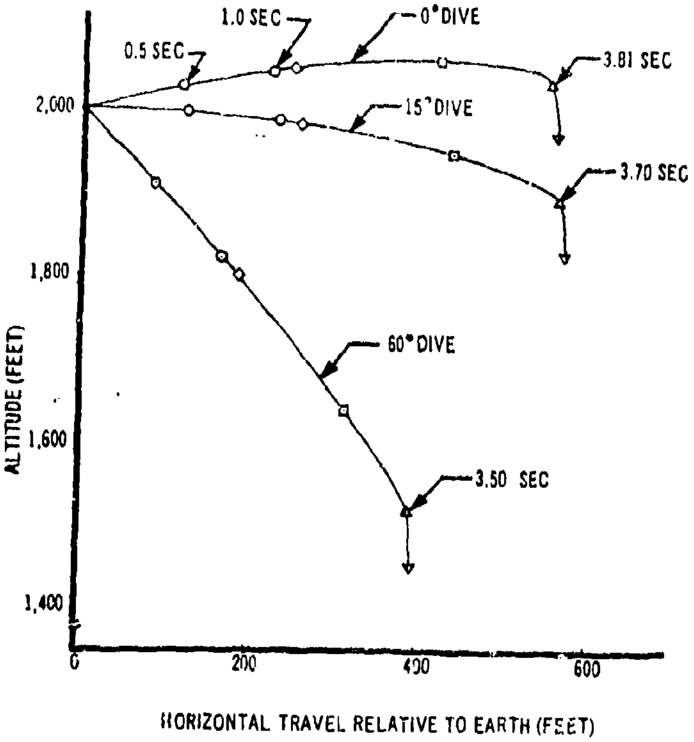
A solid propellant rocket engine (Frankford Arsenal No. XM7) is utilized to eject the capsule from the aircraft. The rocket is 23 inches long by 8 inches diameter and provides a thrust of 9000 pounds in 0.075 second, lasting for an additional 0.625 second for a total impulse of 6000 pound-seconds. The rate of onset of acceleration imparted to the capsule is approximately 200 g/second.



* ZERO DELAY, LOW LEVEL LANYARD CONNECTED

** ONE SECOND DELAY, LOW LEVEL LANYARD NOT CONNECTED. IF CONNECTED, PARACHUTE FAILURE IS LIKELY AND ANEROID BLOCK IS BYPASSED.

Figure 96. B-52 Upward Ejection Seat Lanyard Attachment Flight Conditions



◆ TIME WHEN SEAT AND MAN SEPARATE (1.12 SEC)

■ TIME WHEN PARACHUTE IS FULLY DEPLOYED (1.99 SEC)

▲ TIME WHEN PARACHUTE IS FILLED (NOTED ON CURVE)

↓ END OF CALCUATION (3.0 SEC AFTER PARACHUTE FILLS)

ALL TRAJECTORIES ARE FOR 1-0 SEC SYSTEM
TIME ZERO IS WHEN SEAT CLEARS AIRPLANE

Figure 97. B-52 Seat Occupant Trajectories – Upward Forward Facing Seat – Calculated at 2000 Feet, 150 KCAS

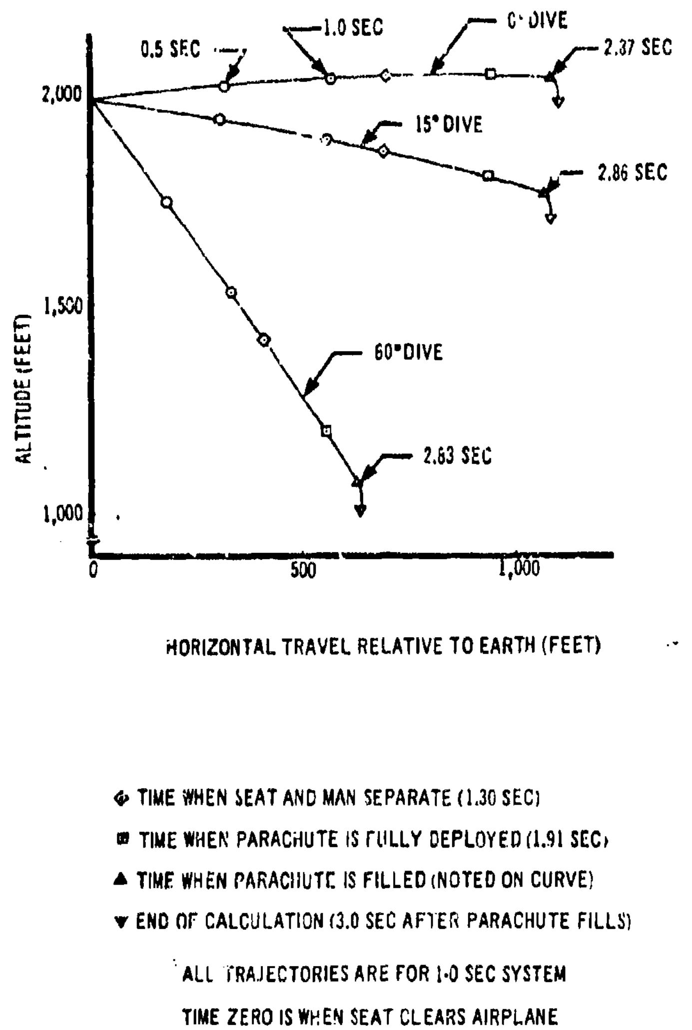


Figure 98. Seat Occupant Trajectories – Upward Forward Facing Seat – Calculated at 2000 Feet, 400 KCAS

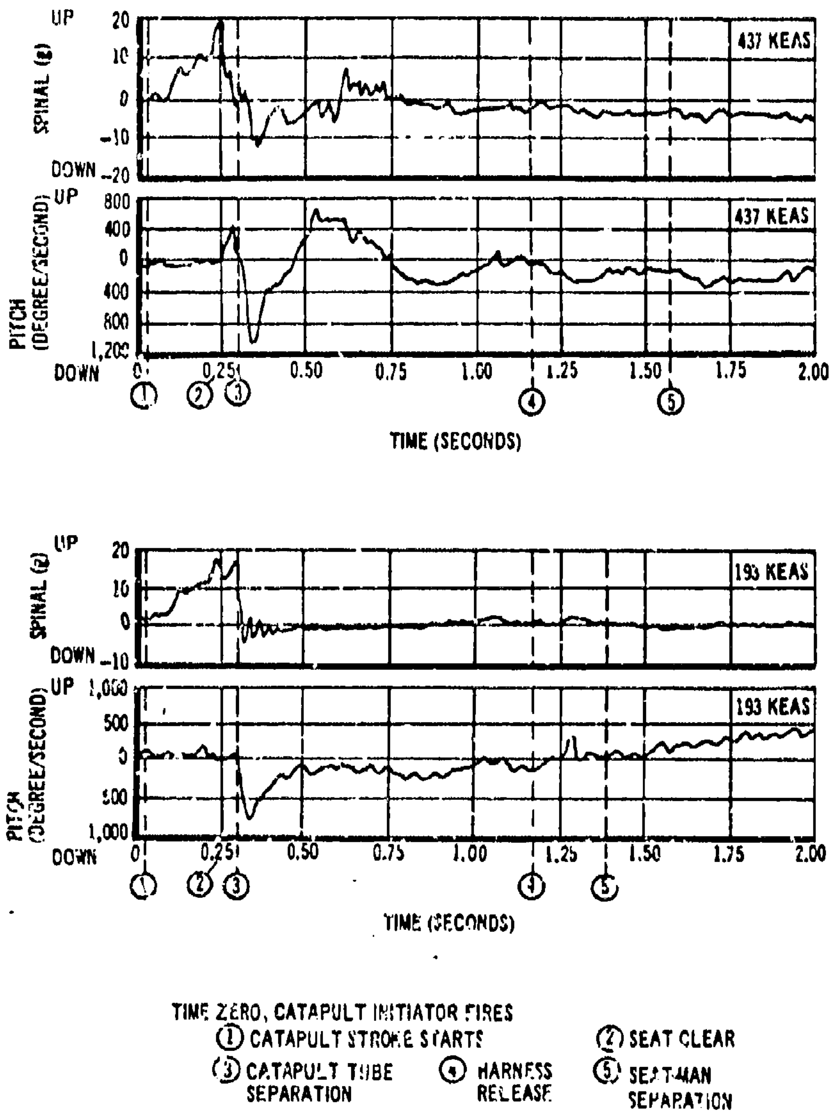


Figure 99. B-52 Upward Seat g Loads and Pitch Rate – Sled Tests

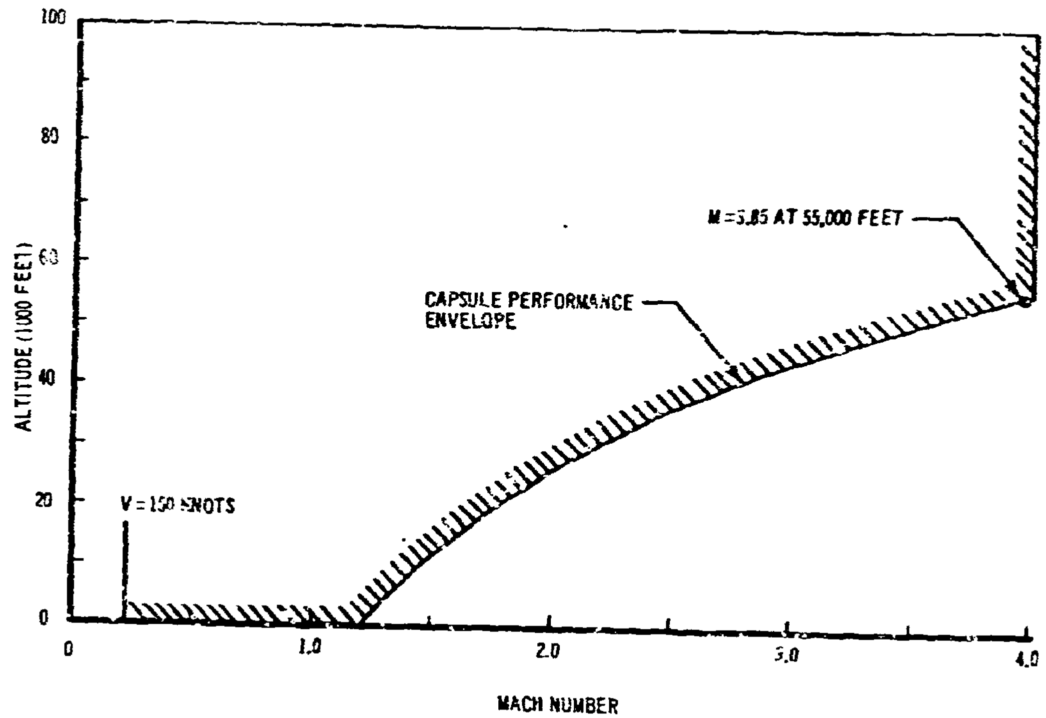
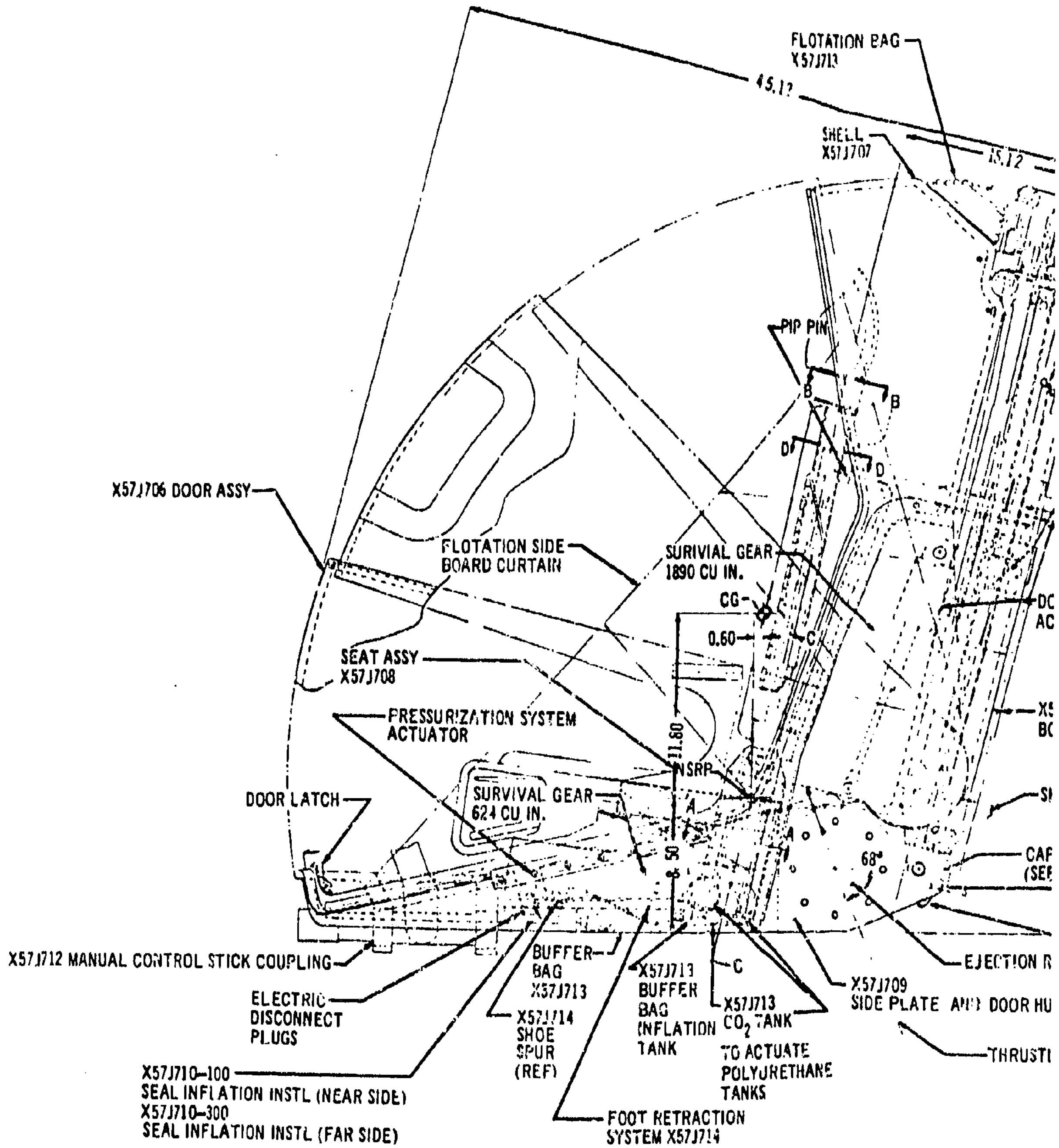


Figure 100. Goodyear Encapsulated Seat Escape System Performance Capability


FLOTATION BAG
X57J713
45.12
SHELL
X57J707
15.12
PIP PIN
B
B
D
D
X57J706 DOOR ASSY
FLOTATION SIDE
BOARD CURTAIN
SURIVIAL GEAR
1890 CU IN.
CG
0.60
C
SEAT ASSY
X57J708
PRESSURIZATION SYSTEM
ACTUATOR
11.80
NSRP
DOOR LATCH
SURVIVAL GEAR
624 CU IN.
A
A
68°
50
X57J712 MANUAL CONTROL STICK COUPLING
ELECTRIC
DISCONNECT
PLUGS
BUFFER
BAG
X57J713
X57J714
SHOE
SPUR
(REF)
X57J713
BUFFER
BAG
INFLATION
TANK
C
X57J713
CO_2 TANK
TO ACTUATE
POLYURETHANE
TANKS
X57J709
SIDE PLATE AND DOOR HU
EJECTION R
THRUSTI
X57J710-100
SEAL INFLATION INSTL (NEAR SIDE)
X57J710-300
SEAL INFLATION INSTL (FAR SIDE)
FOOT RETRACTION
SYSTEM X57J714

H

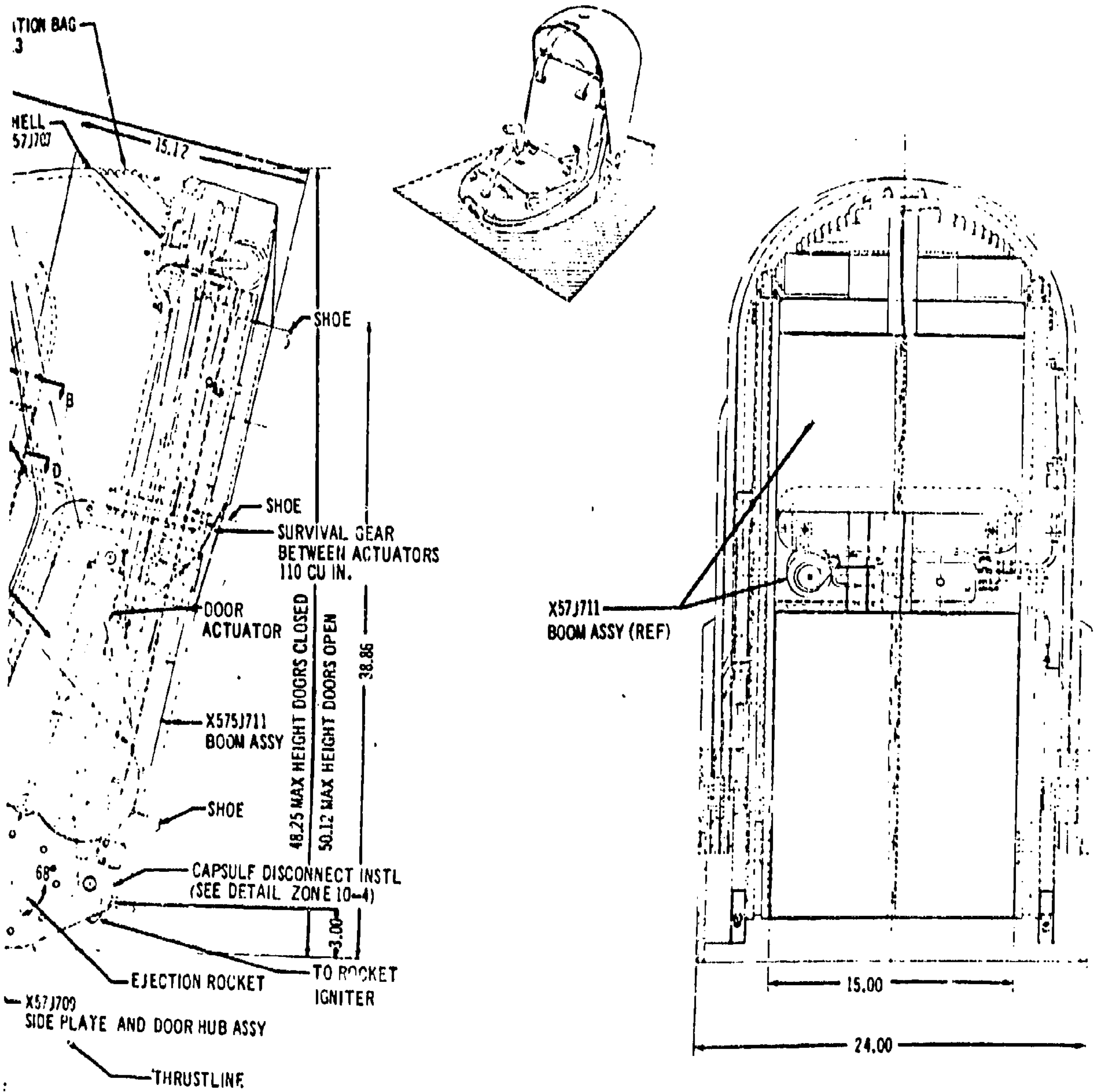
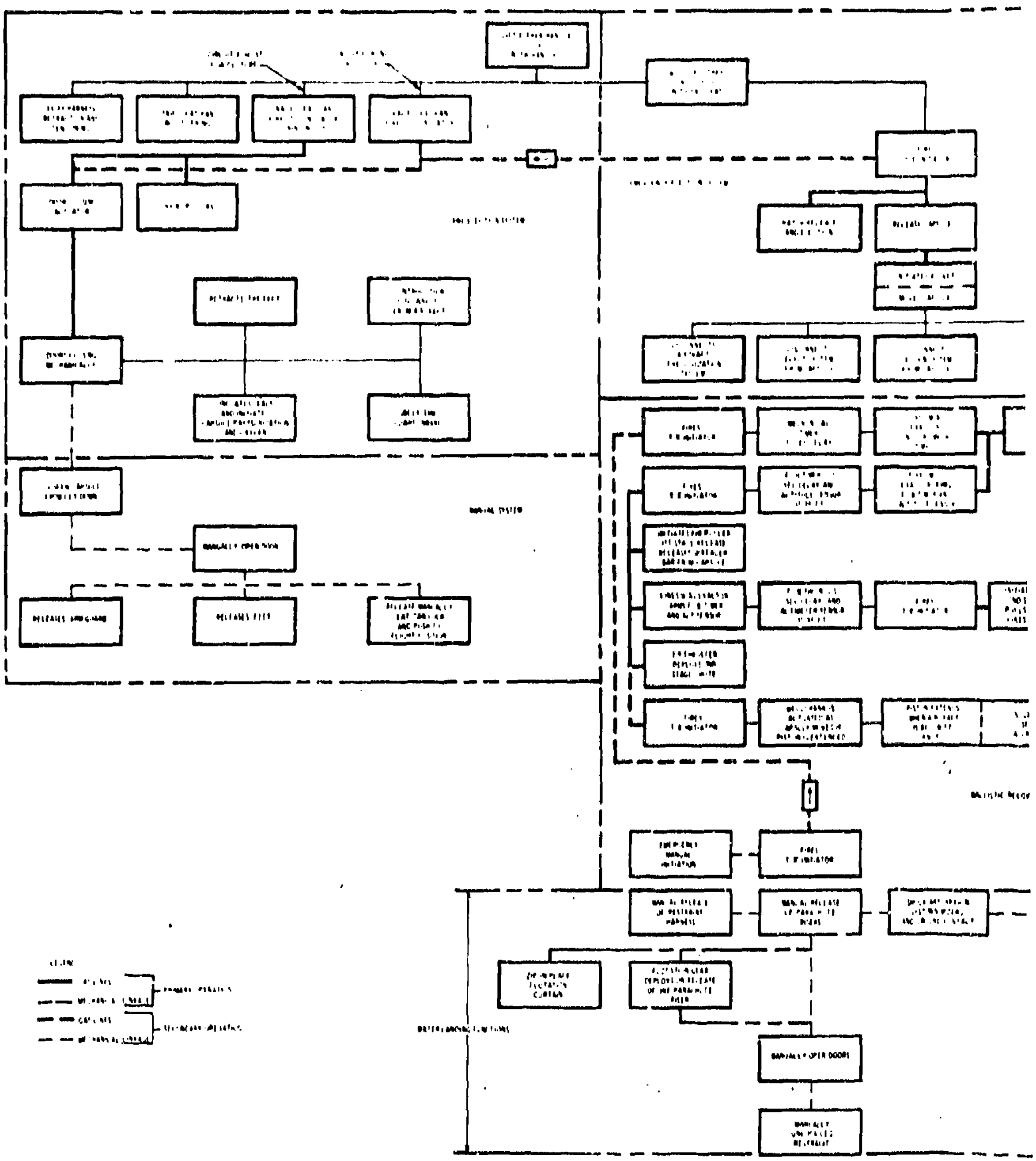


Figure 101. Goodyear Encapsulated Seat – General Arrangement



MANUAL SYSTEM
MANUALLY OPEN VISOR
RELEASES ARM GUARD
RELEASES FEET
FIRES INITIATOR
EMERGENCY MANUAL INITIATION
MANUALLY OPEN DOORS

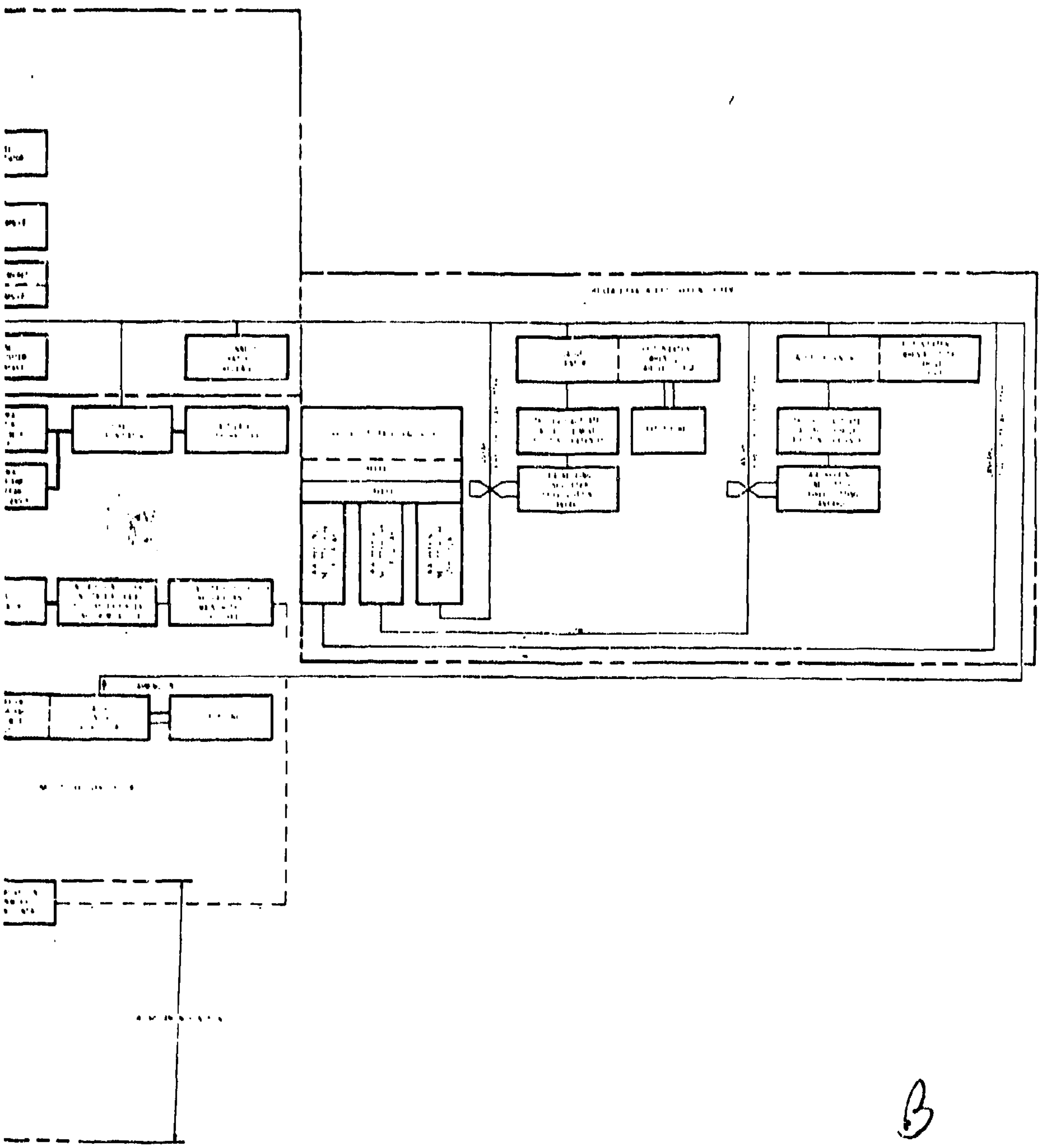


Figure 102. Goodyear Encapsulated Seat – Schematic of Pre-ejection and Ejection Sequencing

The ground impact device consists of a buffer bag attached to the bottom of the capsule. The bag is constructed of nylon-woven Airmat fabric which is coated with neoprene gum. Preset pop-off valves allow metering of the air from the bag during the compression cycle.

The flotation system consists of two float bags, a CO_2 cylinder, two chemical cylinders, a mixing valve, and associated plumbing. Each bag is inflated by polyurethane foam to 6 inches diameter by 24 inches long. In addition to the flotation bags, a set of curtains is provided to increase the capsule freeboard when the doors are open. Fig. 103 shows the capsule with flotation bags inflated during flotation and habitability tests.

Preliminary investigations involving wind tunnel tests and static and dynamic analyses were accomplished to evaluate three favorable stabilization configurations. These consisted of: 1) trailing drag body, 2) inflatable spheres located at the ends of a pair of telescoping booms, and 3) a fin stability system. Each system provides static and dynamic stability in pitch, and, with modification of the initial concepts, provides static yaw stability. Therefore, the selection of the stabilization system was based on weight, volume, and complexity considerations. As a result, the trailing drag body concept was selected. Of two trailing drag body concepts considered, a parachute system offers lightweight and well-proven deployment techniques, but does not possess predictable drag and inflation characteristics above Mach 1.5. An inflatable drag body corrects these deficiencies and was therefore selected for the final analysis, although some penalty in weight and stowage volume results. Figure 104 shows the inflatable drag cone and attachment geometry. The drag cone consists of a fabric membrane attached to inflatable tori and may be deployed in a reefed condition.

The stabilization and recovery system consists of three basic stages: 1) the stabilization drag body, 2) a second-stage conical ribbon parachute, and 3) a 35-foot diameter extended skirt main recovery parachute which is initially deployed in the reefed condition. The deployment sequence and timing of the various stages is dependent on altitude and airspeed at the time of escape initiation. Figure 105 shows the drag areas for the various stages and indicates the deployment and disreefing sequences for the various escape conditions.

The calculated pitch stability characteristics, capsule trajectories relative to aircraft fin, capsule trajectories relative to the ground, and transverse and longitudinal accelerations on the capsule occupant for ejections at Mach 1.2 and 301 knots at sea level are shown in Fig. 106 through 109. These conditions represent the maximum design dynamic pressure condition and the lowest sea level velocity where all three stages are acting.

Table XXIII gives the system weight breakdown.

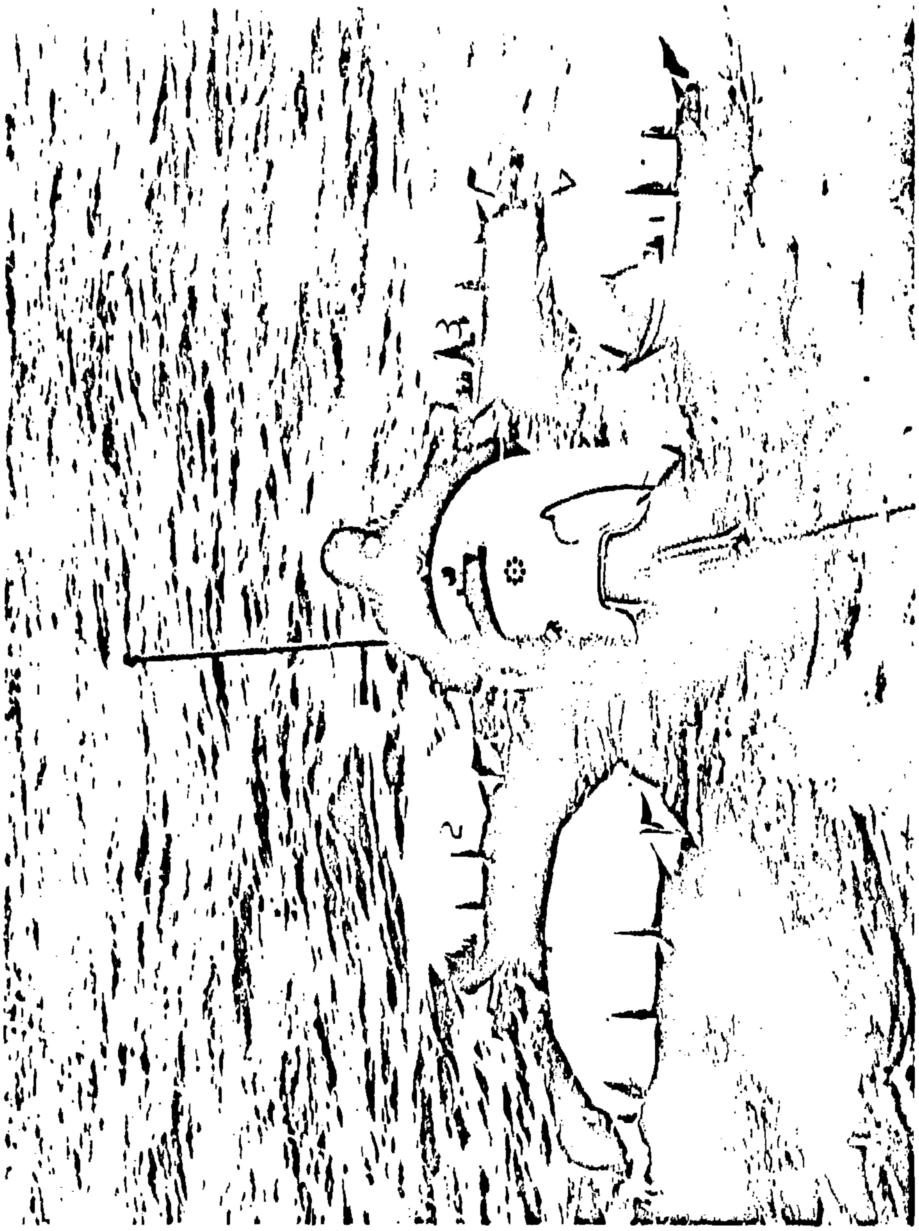
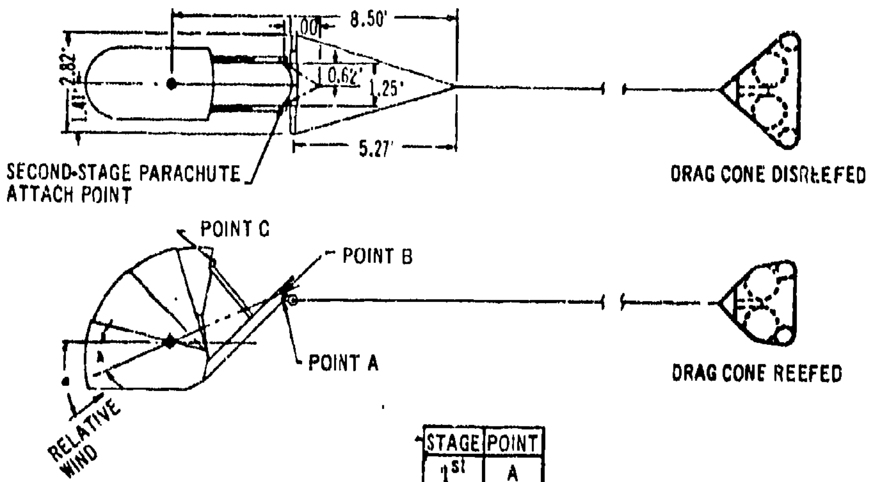


Figure 103. Goodyear Encapsulated Seat during Flotation and Habitability Tests



STAGE	POINT
1st	A
2nd	B
MAIN	C

Figure 104. Goodyear Encapsulated Seat Drag Area Stabilization System Attaching Points

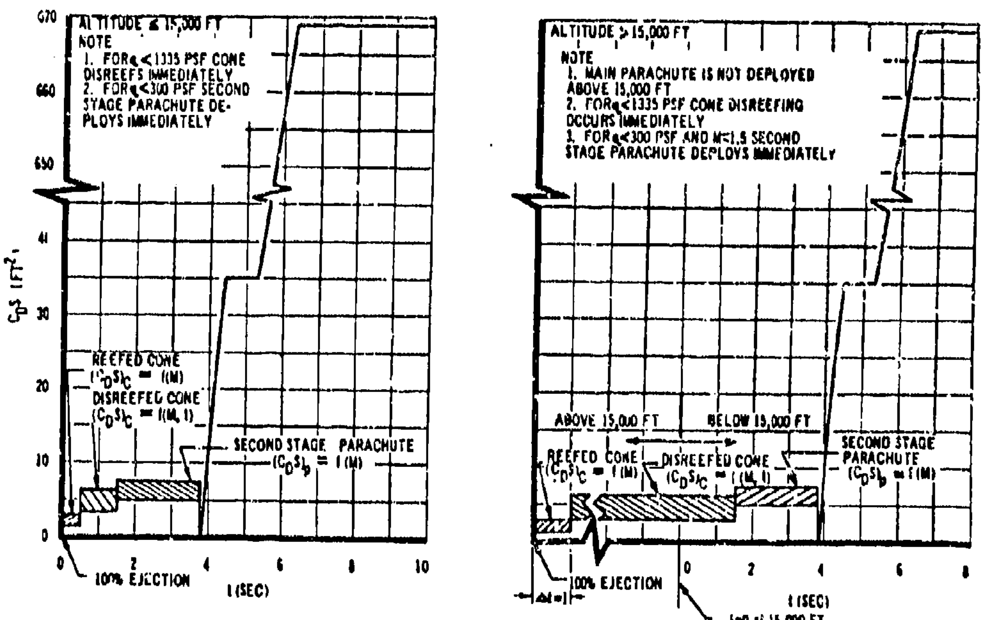


Figure 105. Goodyear Encapsulated Seat Drag Area (C_DS) – Time (t) Histories for Selected Stabilizing System

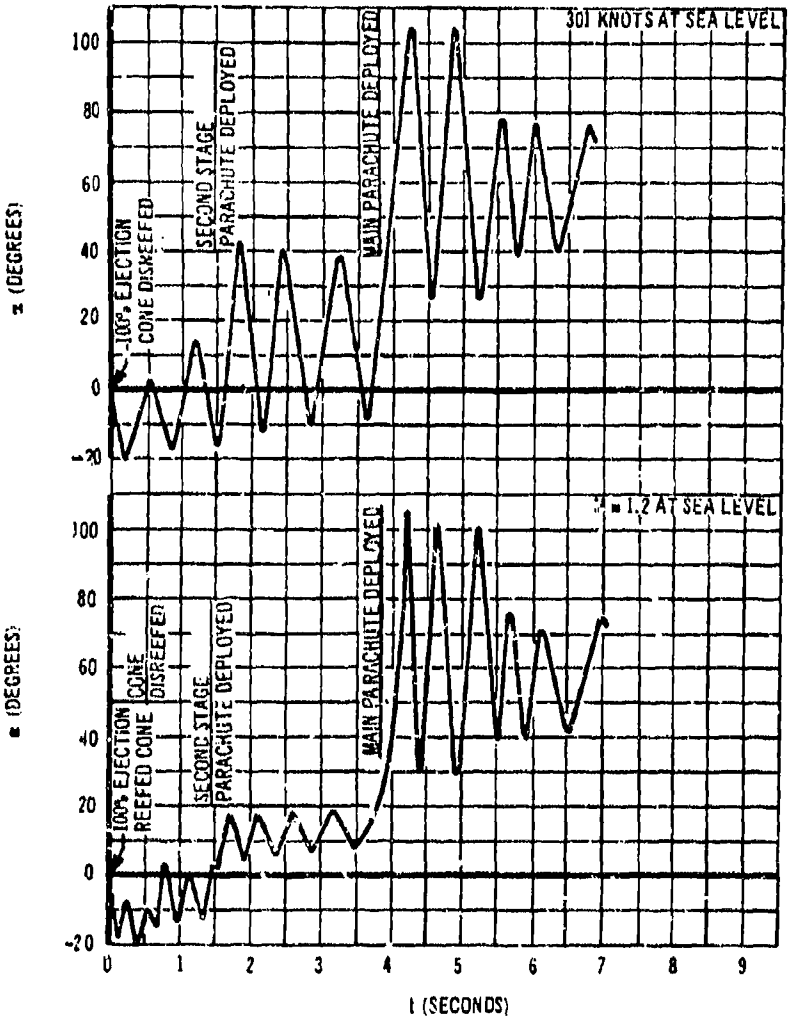


Figure 106. Angle of Attack – Time Histories with Selected Stabilizing System for Various Escape Velocity and Altitude Conditions

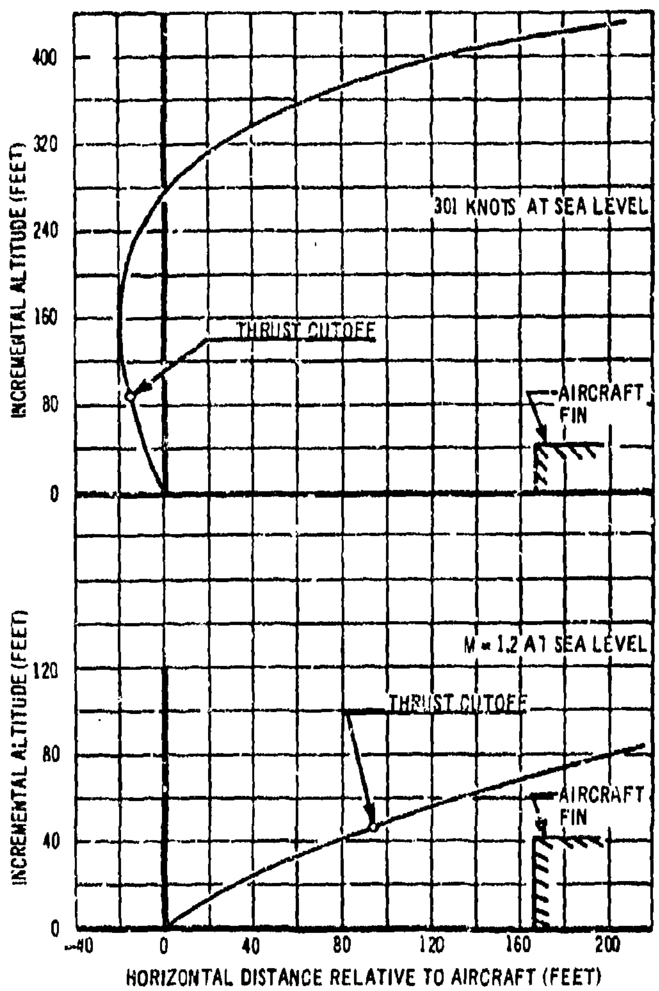


Figure 107. Goodyear Encapsulated Seat Capsule Trajectories Relative to Aircraft at Sea Level

Table XXIII. Goodyear Encapsulated Seat Escape System Weight Breakdown

Item	Weight (Lb)
Shell	46.1
Side plates	17.4
Seat assembly (including recompression, air and emergency oxygen systems, survival drinking water)	43.0
Upper door	2[illegible].6
Middle door	34.7
Lower door	38.9
Brake system	13.0
Seal installation	6.5
Survival equipment	70.0
Foot retracting mechanism	3.0
First-stage drag body	10.5
Second-stage parachute	6.7
Main recovery parachute	20.0
Sequencing hardware	18.7
Stabilization frame assembly	57.6
Buffer bag	10.0
Flotation system	7.7
Rocket	60.0
Man with clothing	200.0
Total	680.4

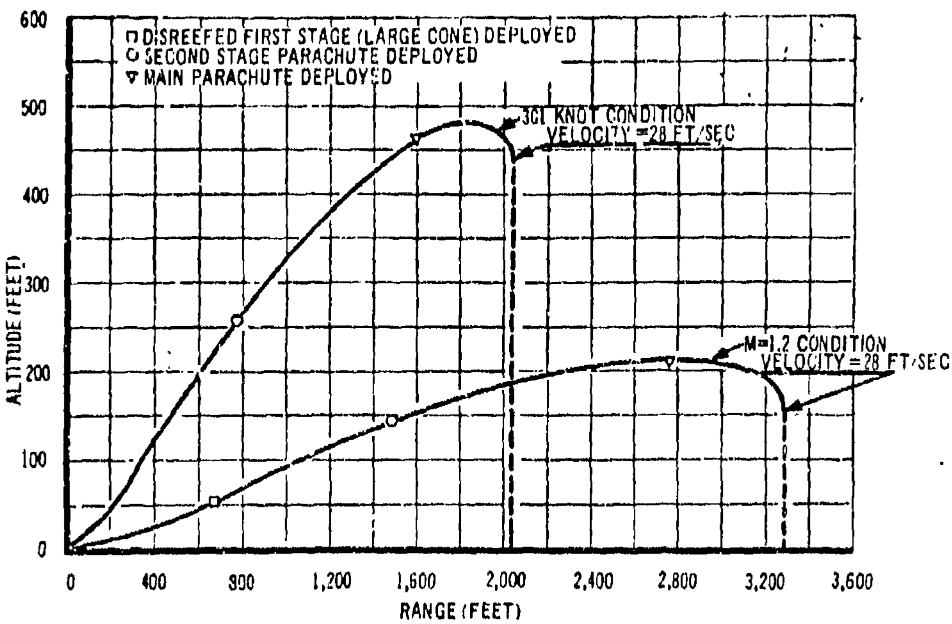


Figure 108. Goodyear Encapsulated Seat – Escape Trajectory at Sea Level

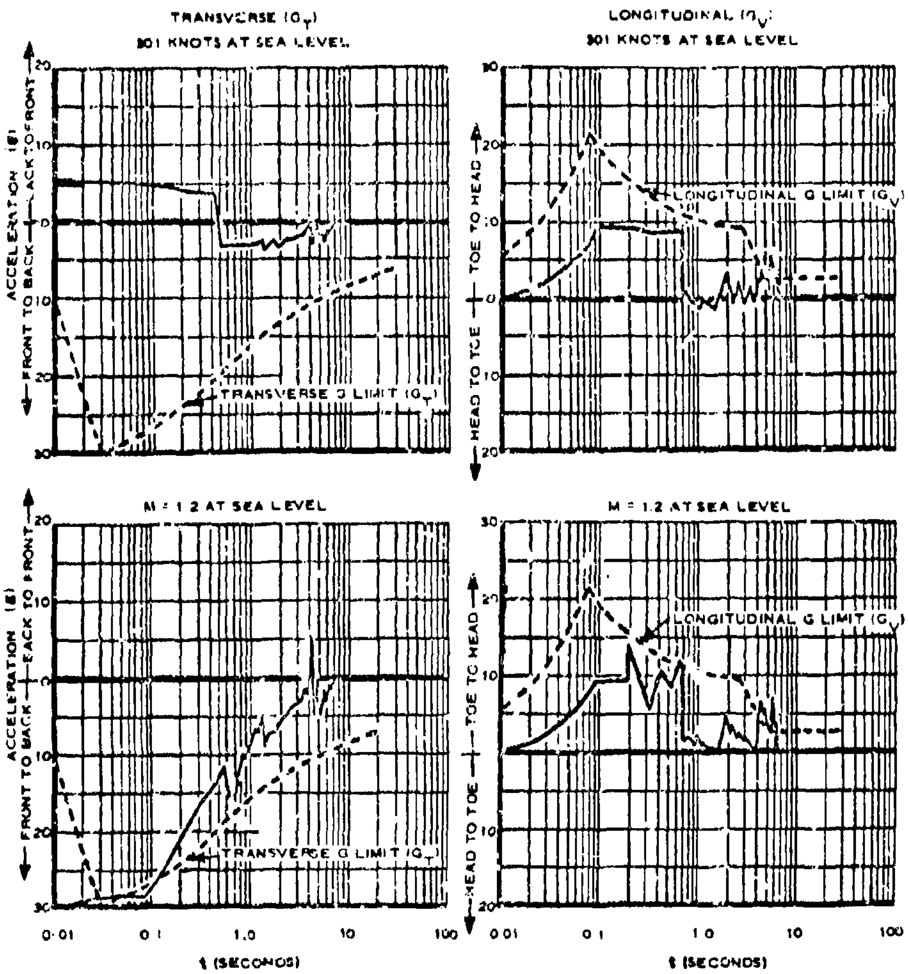


Figure 109. Goodyear Encap 'ated Sect – Transverse (G_T) and Longitudinal (G_V) Acceleration ·e (t) Histories on Occupant in Capsule with Selected S ing System, 301 Knots at Sea Level and M = 1.2 at Sea Level

b. NORTH AMERICAN B-70 ENCAPSULATED SEAT

There are two crew stations, side-by-side, in the XB-70A airplane. Each crewman is provided with an encapsulated seat (Fig. 110) for emergency escape. Upon entering the seat, the crewman connects the one-point oxygen and communication lead and the torso-hip restraint harness at two fittings. Other than these devices, there is no tie to the occupant.

The major subsystems incorporated in the escape capsule are the rocket catapult, torso restraint, stabilization booms and parachutes, pressurization system, and recovery system. The seat is 20 inches wide at the hips and 21.25 inches wide at the elbows and shoulders. Figure 111 shows the overall installation dimensions and Table XXIV shows the weight breakdown of the capsule. To reduce fatigue during flight, arm rests are provided and the seat may be reclined, electrically raised and lowered, and the under-thigh surface may be varied.

The seat occupant in normal flight (Fig. 112) sits well forward of the capsule shell and is able to perform flight duties unrestricted. Actuation of either of two control levers ballistically retracts the seat and crewman into the shell, closes the clamshell doors from top and bottom, and pressurizes the capsule. From this position the pilot can monitor the instrument panel and control the airplane, or he may eject by squeezing one of two triggers at his side. The retracting-enclosing sequence may be performed alternately by hand and may be reversed to restore the crewman to his usual position.

Operation of either handgrip trigger jettisons the individual overhead hatch and, in sequence, ejects the capsule by firing the rocket-catapult, which produces an impulse of 4500 pound-seconds. Within one-tenth second after ejection, a pair of cylindrical booms rotate and extend to a length of nine feet from the capsule back, imparting medium- and high-speed aerodynamic stability to the capsule. A photograph of the capsule in flight during rocket burning is shown in Fig. 113. For increased stability during low-speed ejections and for free-fall, a parachute deploys from each boom tip 1.5 seconds after extension. The main recovery parachute is deployed 1.9 seconds after ejection below 15,500 feet; if above 15,000 feet, the parachute withholds deployment until the capsule descends to this altitude. A radio homing beacon is actuated upon parachute deployment. To reduce opening loads and to ensure uniform inflation, the 34.5-foot solid canopy with 10 percent extended skirt parachute is reefed for two seconds. A cautionary light illuminates within the capsule at 15,500 feet to inform the occupant that parachute opening altitude has been reached and deployment may be initiated manually, if necessary.

During descent the capsule is in an upright attitude, as shown in Fig. 114, and contacts the ground or water in this position. One second after main parachute deployment, a bladder inflates from the bottom of the capsule to attenuate landing loads and, in conjunction with the stabilization booms, to bring the capsule to a rest position affording rapid exit. The occupant may collapse the parachute to avoid dragging the capsule during high winds. Egress can be accomplished by raising the upper door or by explosively separating both doors.

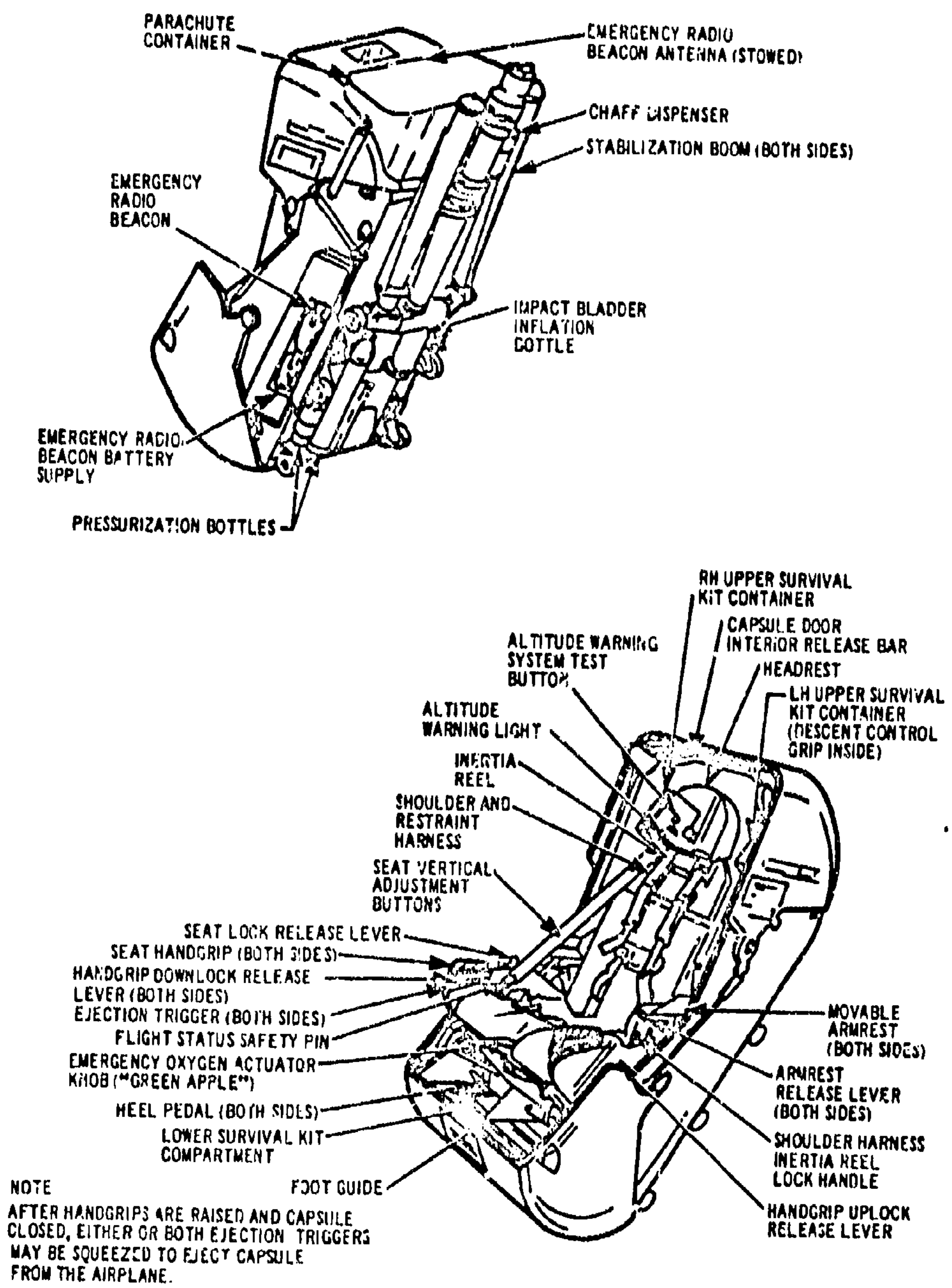


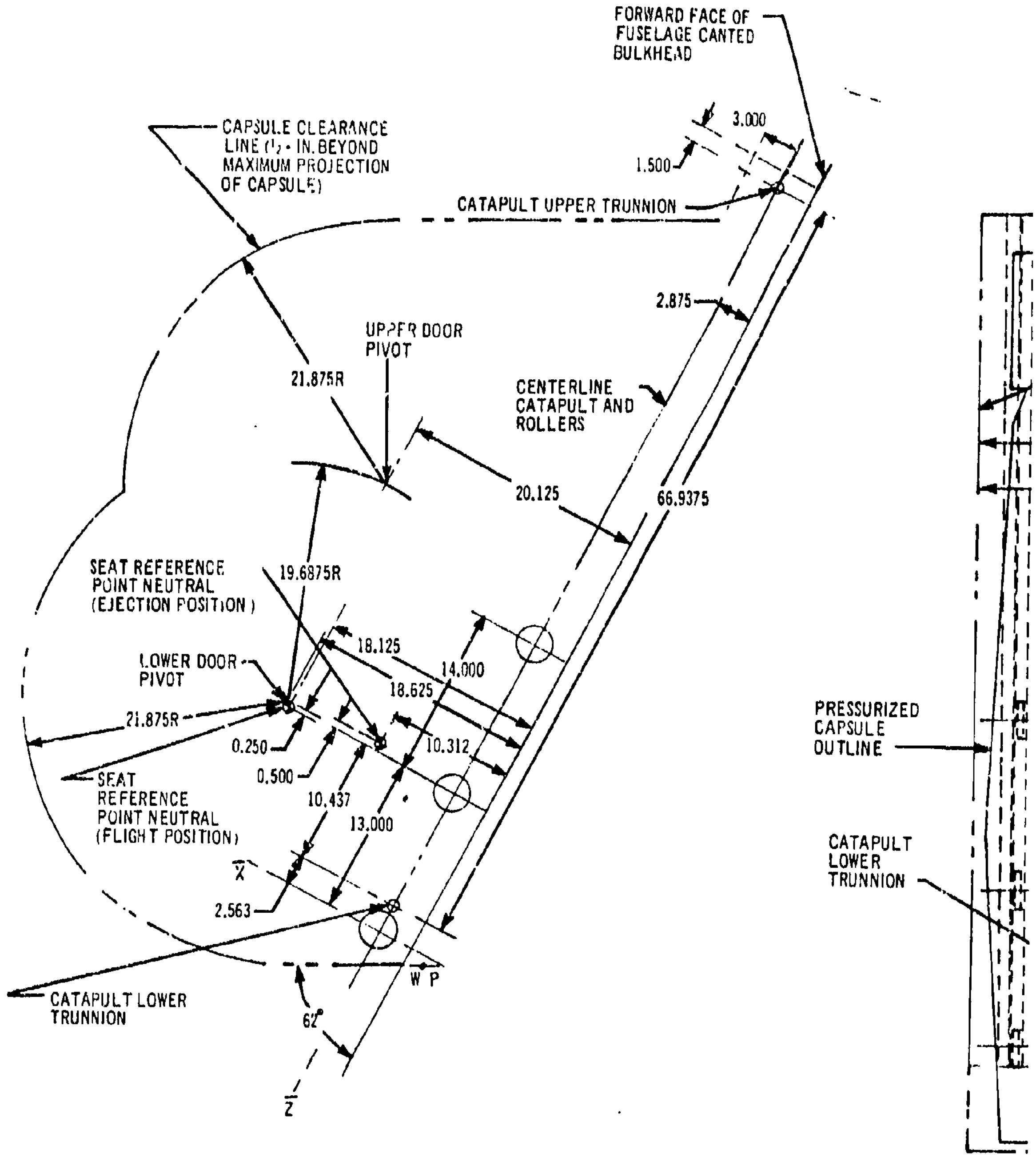
Figure 110. North American B-70 Escape Capsule

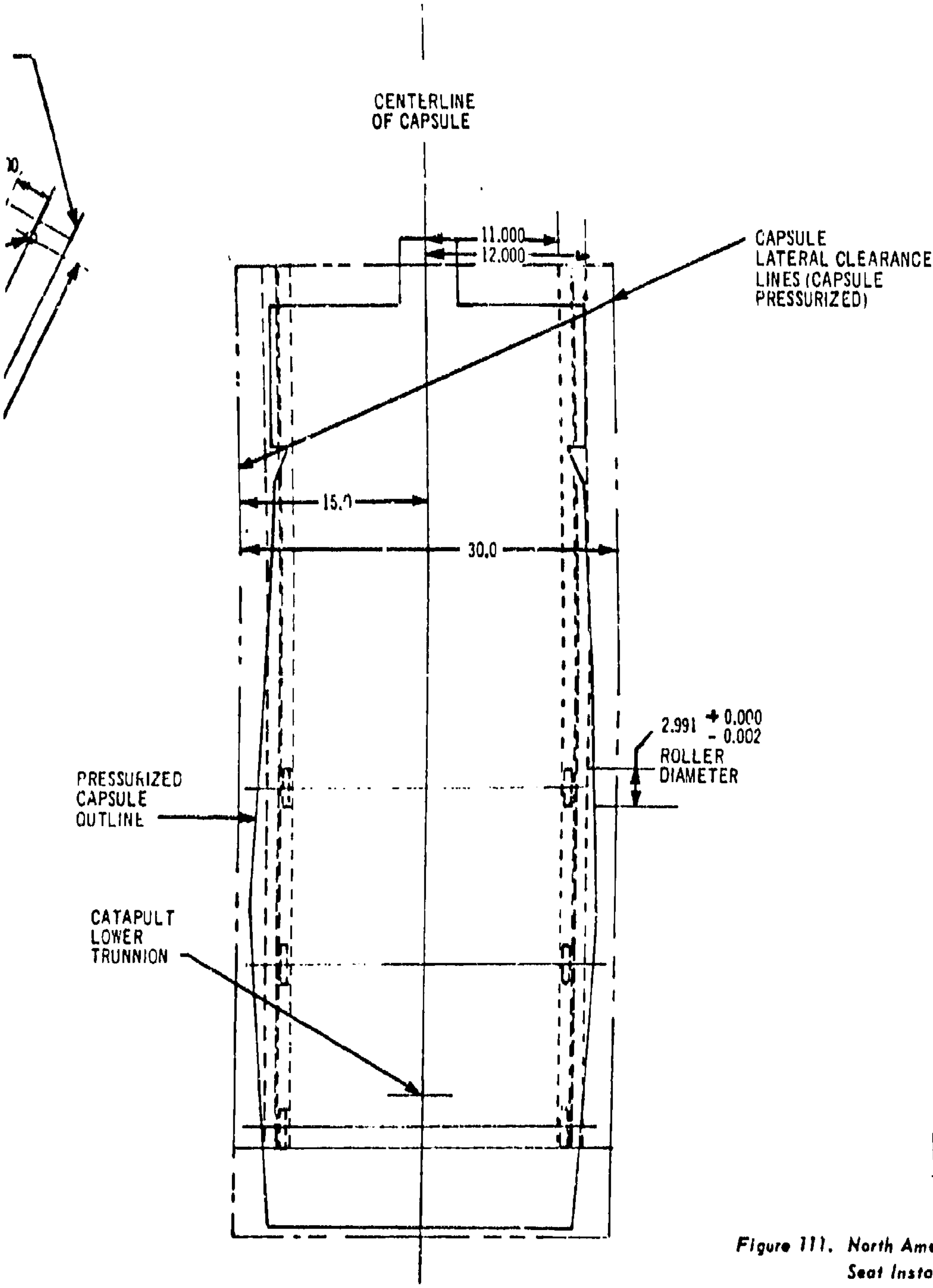
Table XXIV. North American B-70 Encapsulated Seat Weight Breakdown

	Weight (Lb) Ejectable	Weight (Lb) Nonejectable
Capsule structure	208	
Seat	67	
Catapult inner tube and propellant	38	
Stabilization booms	102	
Recovery parachute installation (parachute = 31 pounds)	38	
Oxygen installation	35	
Impact attenuator installation	17	
Cartridge devices, hoses and fittings	24	
Miscellaneous (capsule)	33	
Clothes and personnel equipment	12	
Survival gear	27	
Catapult outer tube		13
Ejection rails		36
Miscellaneous (airplane)		14
Ejectable Weight	601	
Nonejectable Weight		63
Total Installed Weight	664	

Crewmember Weight (Lb)

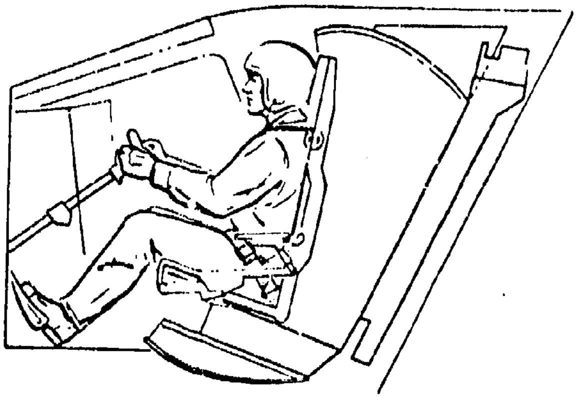
5 Percentile	134
50 Percentile	162
95 Percentile	200


FORWARD FACE OF FUSELAGE CANTED BULKHEAD
CAPSULE CLEARANCE LINE (½ - IN. BEYOND MAXIMUM PROJECTION OF CAPSULE)
3.000
1.500
CATAPULT UPPER TRUNNION
2.875
UPPER DOOR PIVOT
21.875R
CENTERLINE CATAPULT AND ROLLERS
20.125
66.9375
SEAT REFERENCE POINT NEUTRAL (EJECTION POSITION)
19.6875R
18.125
LOWER DOOR PIVOT
14.000
18.625
21.875R
10.312
0.250
0.500
SEAT REFERENCE POINT NEUTRAL (FLIGHT POSITION)
10.437
13.000
X
2.563
CATAPULT LOWER TRUNNION
W P
62°
Z
PRESSURIZED CAPSULE OUTLINE
CATAPULT LOWER TRUNNION



B

Figure 111. North American B-70 Encapsulated Seat Installation Dimensions



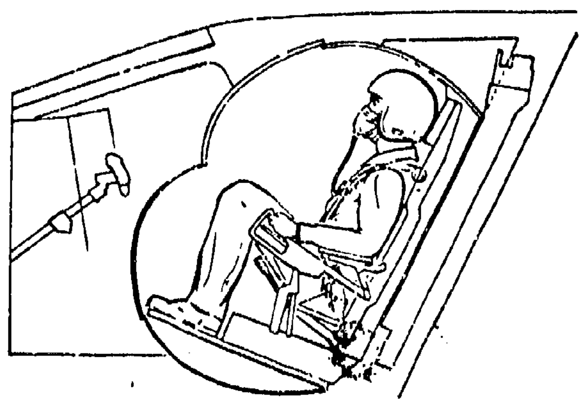


Figure 112. B-70 Seat Operation

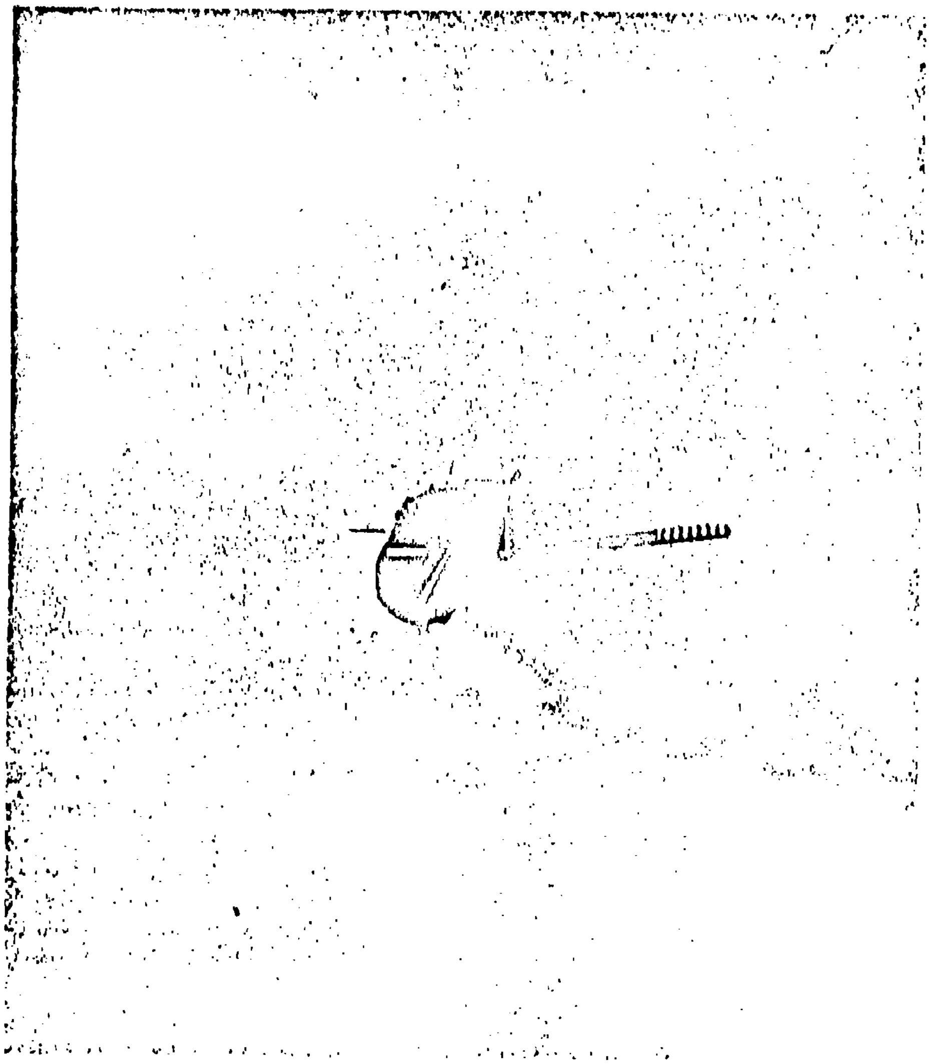


Figure 113. B-70 Encapsulated Seat -- In-Flight

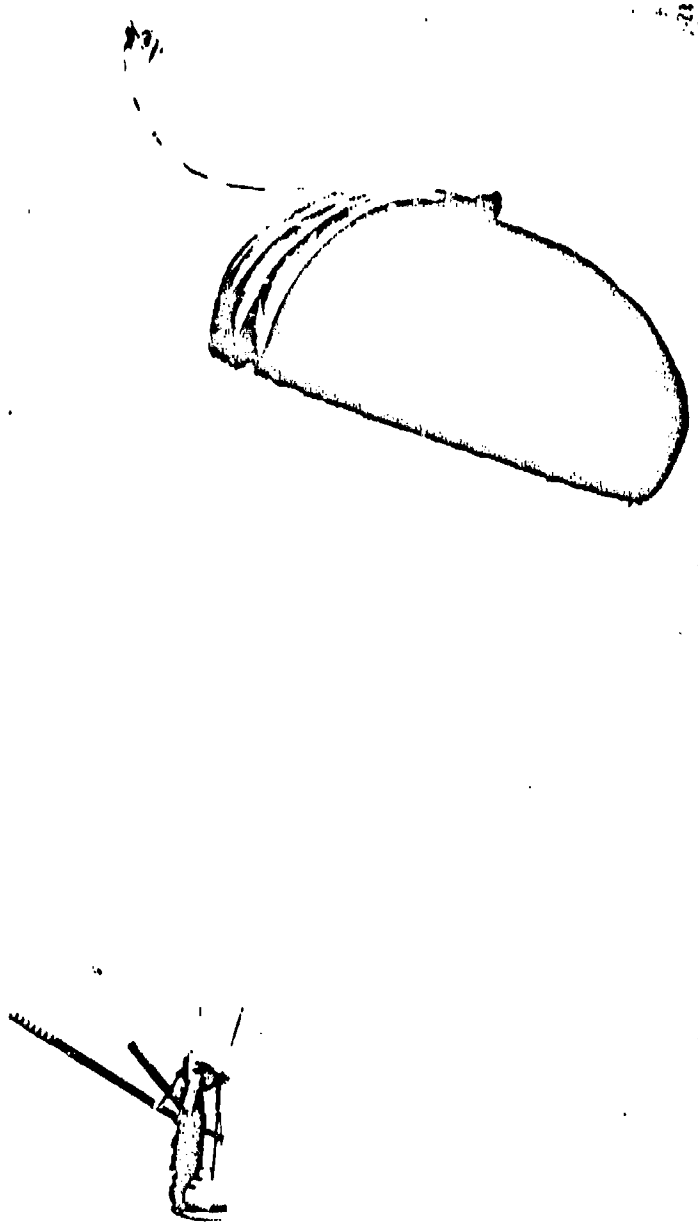


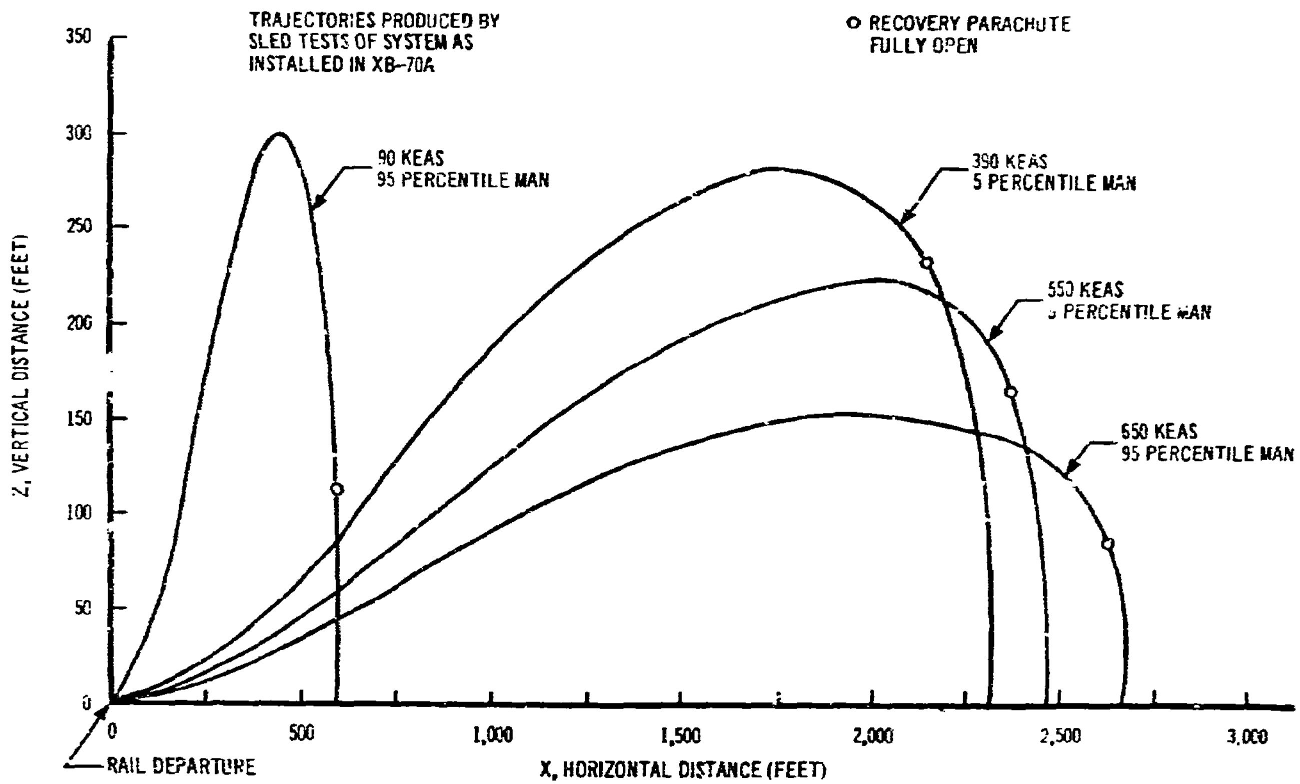
Figure 114. B-70 Encapsulated Seat with Parachute Fully Inflated

All survival equipment is readily available to the seated occupant within the enclosed capsule. The equipment is stowed in two containers beside the crewman's head and in an underseat compartment. After water landings the capsule floats stably in the supine position, allowing the crewman to scan the horizon and sky through the three capsule windows while awaiting rescue.

A complete developmental and qualification test program was accomplished on the capsule and the capsule subsystems. The complete system was demonstrated in 32 ejection tests which simulated escape conditions covering the complete XB-70A flight envelope. Nineteen ejections were accomplished in flight, eleven from sleds, and two from a static ground position. Typical test trajectories demonstrating the system's capability are shown in Fig. 115. The event-time-sequence history recorded during a 93 KEAS test was as follows:

Event	Seconds
Ejection initiation	0.0
Capsule first motion	0.022
Tripper actuation	0.145
Stabilization booms unlock	0.173
Upper roller tipoff	0.177
Catapult tube separation	0.195
Center roller tipoff	0.196
Lower roller tipoff	0.214
Stabilization booms fully rotated	0.227
Stabilization booms fully extended	0.264
Rocket catapult burnout	0.73
Stabilization boom parachute caps fired	1.83
Recovery parachute lid fired	2.27
Impact attenuator door jettisoned	3.56
Recovery parachute line stretch	3.70
Recovery parachute reefed open	5.47
Impact attenuator fully inflated	5.96
Recovery parachute disreefed	6.85
Recovery parachute fully open	7.98
Capsule touchdown	11.05

Capsule accelerations are moderated by aerodynamic characteristics, recovery parachute reefing, and by the gas-filled bag landing impact attenuator. The most severe conditions result in maximum force applications of 21 g seat-to-head and 15 g chest-to-back during ejection of a 5 percentile occupant at maximum indicated airspeed. Accelerations experienced during and immediately following capsule ejections during a low- and high-speed sled test are shown in Figs. 116 and 117. Since the ejected capsule trims aerodynamically at an angle close to the zero lift attitude, the variations in vertical accelerations are small with changes in airspeed. During deployment and inflation of the recovery parachute a maximum of approximately 11 g (at reefed open time) was recorded with force applications from seat-to-head predominating. Touchdown applied forces, recorded by instrumentation near the mass center-of-gravity during water entry, peak to 7 g seat-to-head and 4 g chest-to-back and laterally, while accelerations upon drifting contact onto decomposed granite and vertical approach onto concrete reach maximums of 12 g seat-to-head and chest-to-back



NOTE $\frac{X}{Z}$ SCALE DIFFERENTIAL IS $\frac{5}{1}$

Figure 115. B-70 Escape Capsule – Four Representative Trajectories

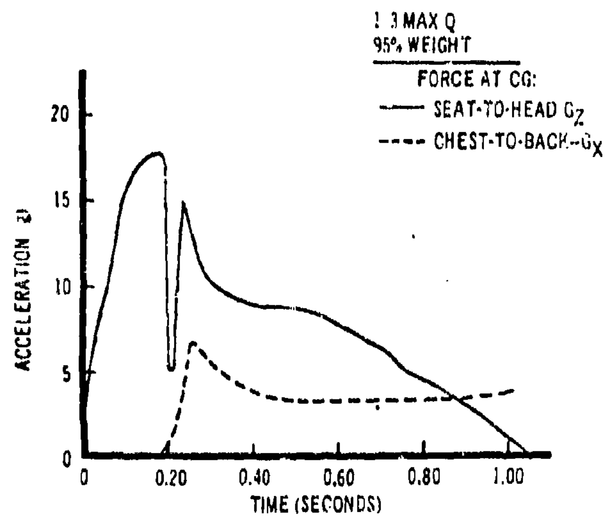


Figure 116. Ejection Exit Histories – B-70 Escape Capsule Ejection Accelerations

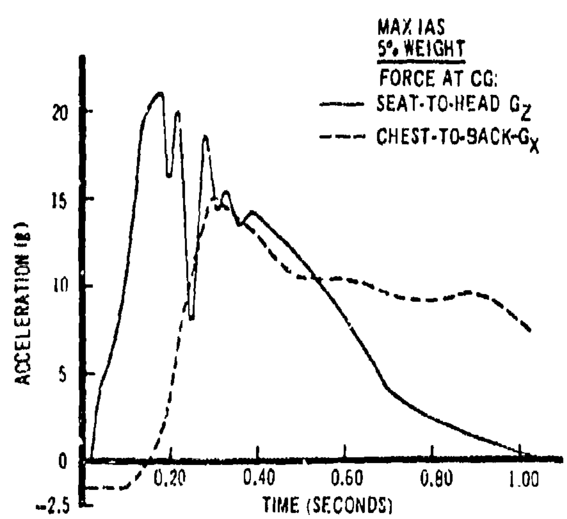


Figure 117. Ejection Exit Histories – B-70 Escape Capsule Ejection Accelerations

with 6 g laterally. Imposition of a 16-knot wind drift onto concrete raises maximum to 19 g seat-to-head and 9 g chest-to-back and laterally.

The encapsulated seat will provide safe escape throughout a speed range from 90 KEAS to supersonic and from ground level to altitudes exceeding 100,000 feet. The escape system's capability envelope is shown in Fig. 118. By addition of an alternative manual control and/or a speed-altitude sensor, the XB-70A encapsulated seat can be easily modified to achieve safe escape at zero-speed, zero-altitude.

e. STANLEY B-58 ENCAPSULATED SEAT

The B-58 encapsulated seat was developed and manufactured by the Stanley Aviation Corporation under Air Force contracts for the Convair Division of General Dynamics Corporation. Development of the encapsulated seat escape system began in September 1958 and consisted of the following system tests:

- 5 static firings; one from a B-58 aircraft, and the remainder from test rigs.
- 2 drop tests from a balloon gondola at 88,000 feet.
- 33 single ejections and 15 dual ejections from a rocket propelled sled. The sled test velocities ranged from 97 knots to approximately 690 knots.
- 13 or more ejections from a production B-58 aircraft at conditions from 100 knots taxiing on the runway to Mach 1.6 at 45,000 feet.
- 14 drop tests from a B-47 aircraft at a maximum altitude of approximately 47,000 feet.
- 16 slow-speed reliability drop tests from a T-28 aircraft.

The B-58 encapsulated seat escape system provides safe escape for a crewman at speeds up to 600 knots at sea level and up to Mach 2.2 at altitudes up to 80,000 feet. Ground level escape is provided at speeds between 100 and 285 knots. The escape capability is shown in Fig. 119. A proposal for zero-zero capability is presented in Ref. 5. The encapsulated seat dimensions are shown in Fig. 120. The arrangement of the encapsulated seat is shown in Fig. 121.

The B-58 capsule functions much like an open ejection seat during normal flight, except that a pressure suit is not worn by the occupant. If pressurization is lost, the crewmember pulls a handle, along either side of the seat, to initiate encapsulation and pressurization. The airplane may be flown, from within the encapsulated seat, down to lower altitudes where pressurization is not required, using basic controls contained within the capsule. Encapsulation may be reversed and repeated. Escape is initiated by pulling either trigger under the pre-ejection handles. This results in jettisoning of the canopy. The capsule is boosted by a rocket-catapult, and stabilized by a drogue parachute and fins attached to a frame to provide adequate moment arm. An initially reefed recovery parachute is deployed after a suitable time delay for speed

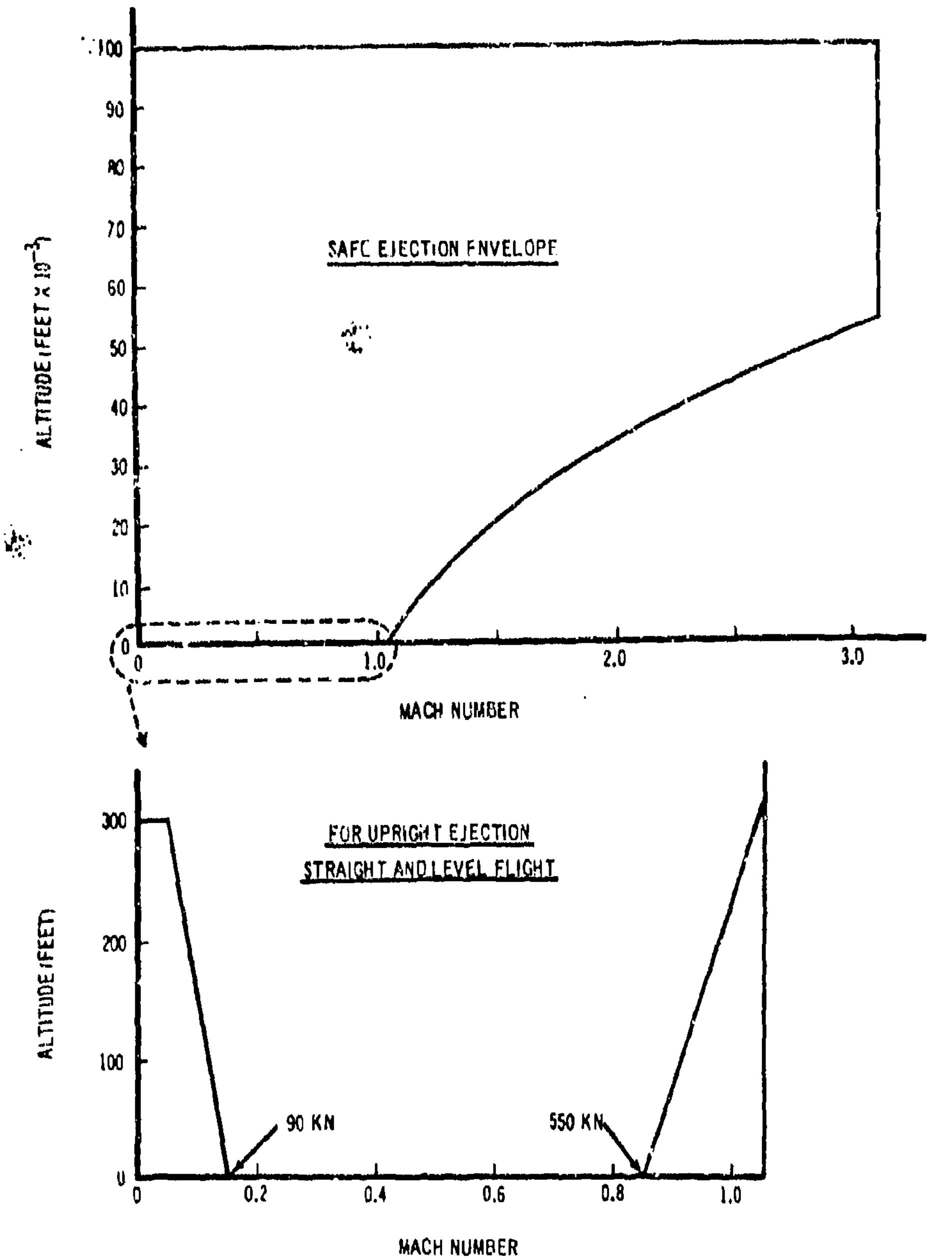


Figure 118. B-70 Escape Capsule Safe Ejection Envelope

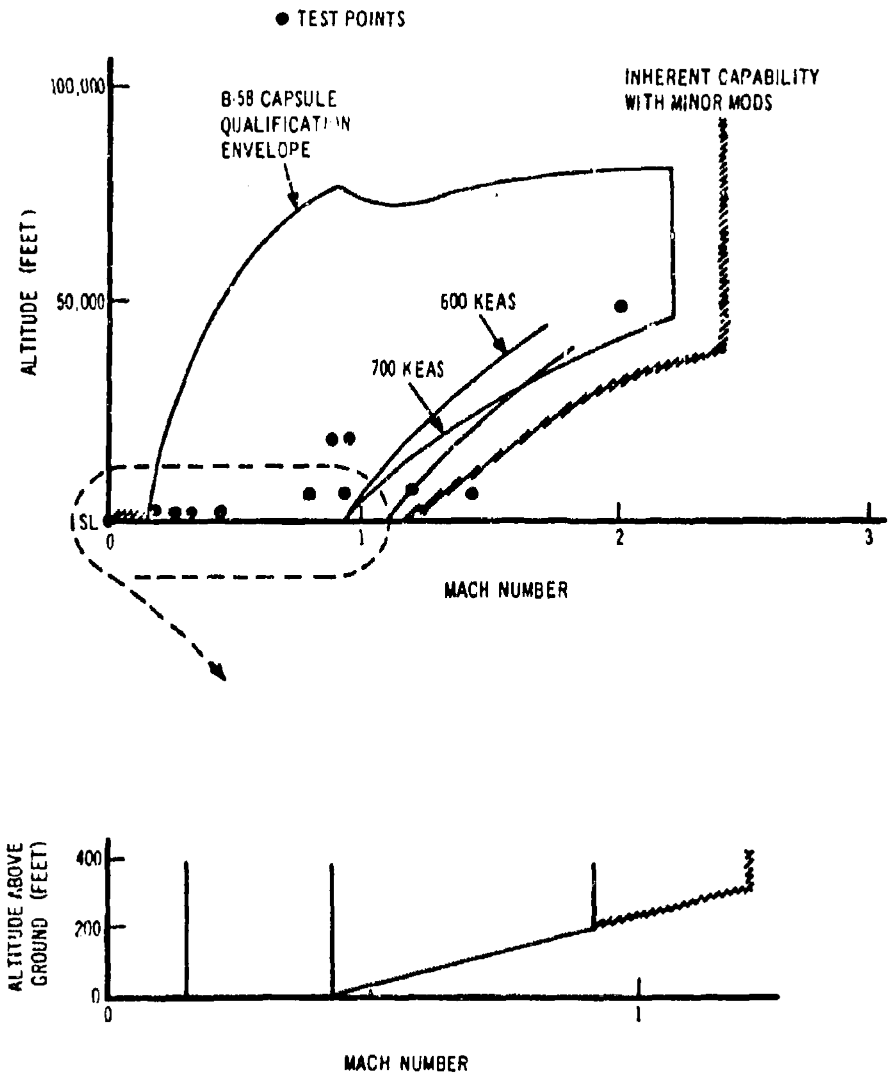


Figure 119. Stanley B-58 Encapsulated Seat – Capability

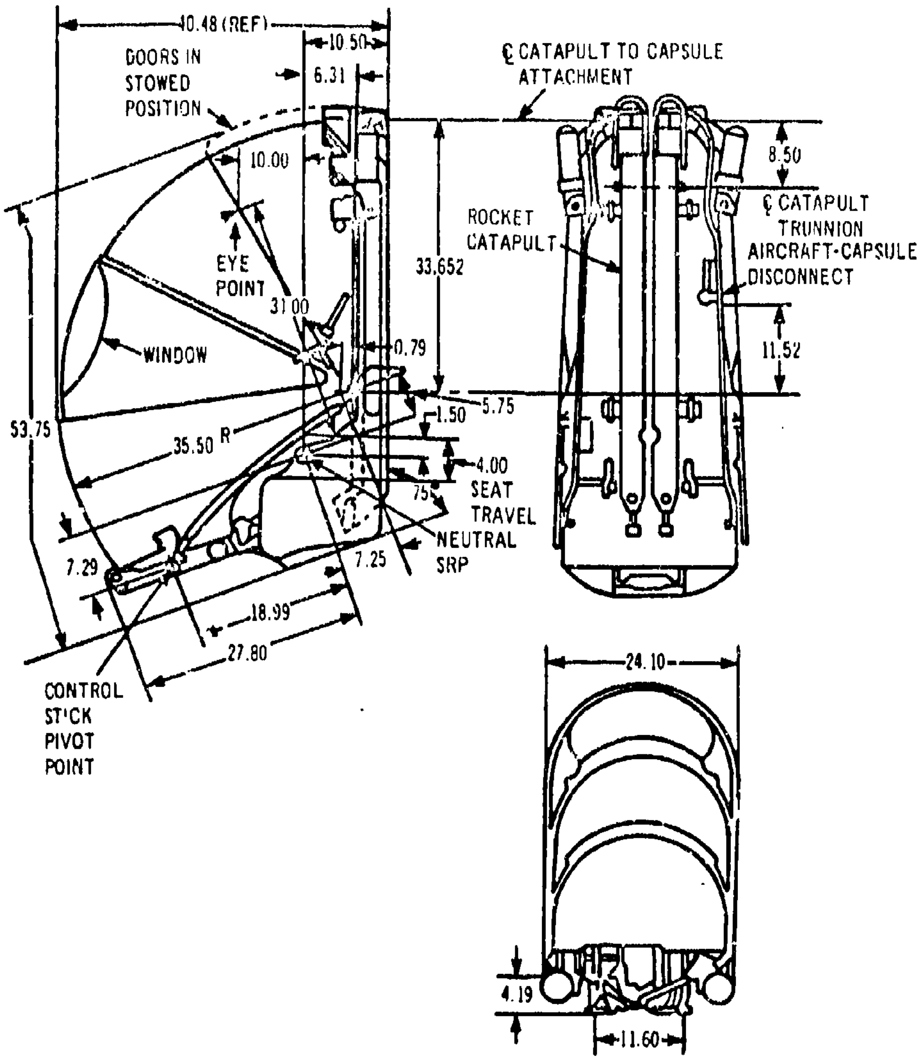


Figure 120. Stanley B-58 Encapsulated Seat – Dimensions

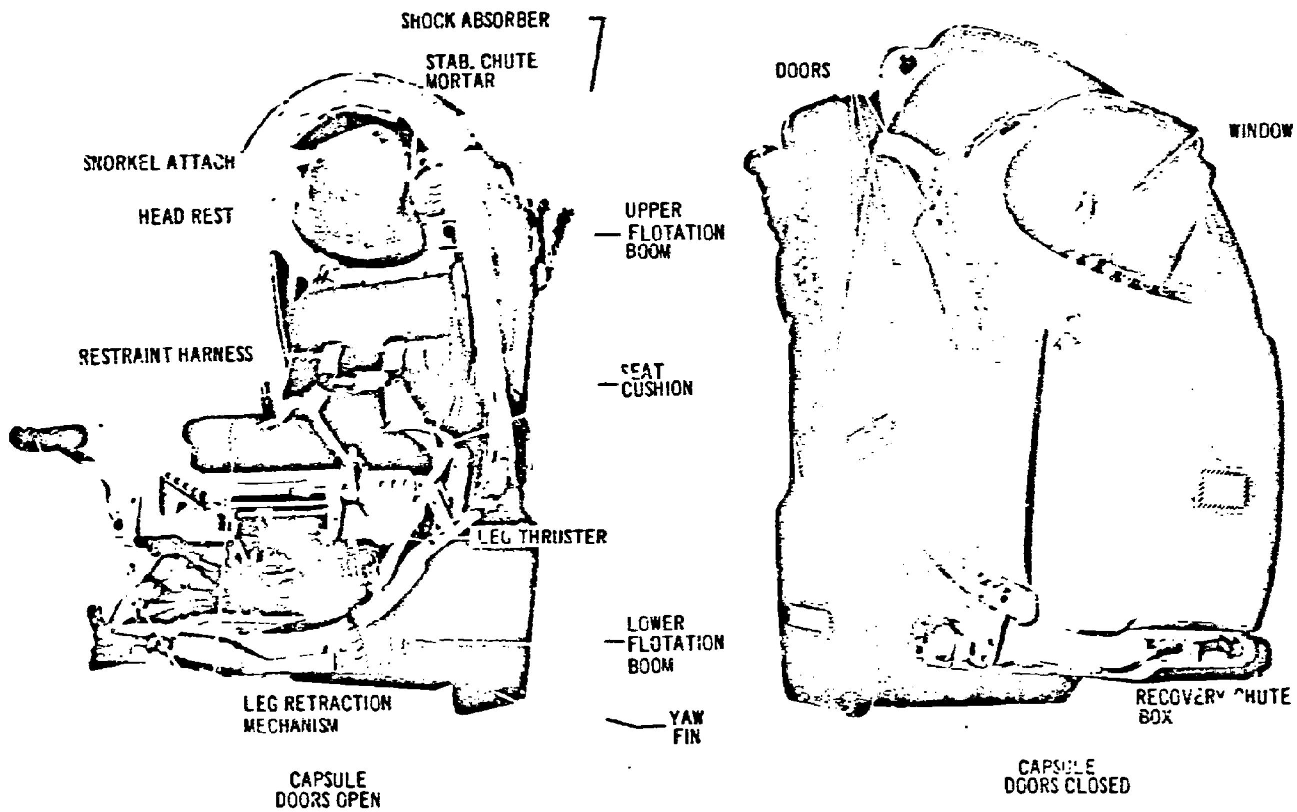


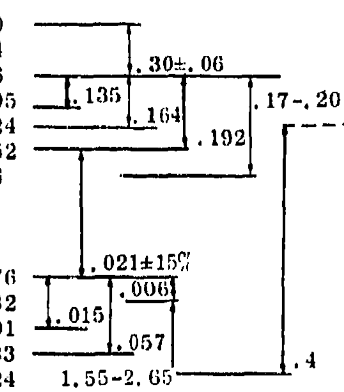
Figure 121. Stanley B-58 Encapsulated Seat

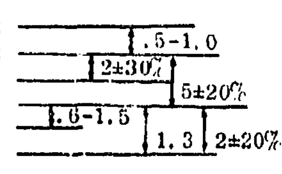
decay or to allow the capsule to descend to below 15,000-foot altitude. Landing impact is absorbed by two yielding metal cylinders plus cutting of flanges by the stabilization frame fins, which are retracted to the landing position after recovery parachute deployment. Four flotation booms augment buoyancy in case of a water landing. The sequence of events during ejection and recovery is shown in Fig. 122. The escape sequence times are summarized in Table XXV. A systems schematic is shown in Fig. 123.

Table XXV. Stanley B-58 Encapsulated Seat Operation Sequence Times

Below 15,000 Feet

	Maximum Time (Seconds)
Pre-Ejection	
Handle pulled	0.0
Legs retract	0.6
Doors close	1.0
Capsule pressurizes	7.0
Ejection	
Trigger pulled	0.00
Canopy jettisons	0.04
Catapult fires	0.36
Stabilization chute deploys	0.495
Rocket fires	0.524
Battery rail switch trips	0.552
Capsule full emergence	0.56
Stabilization	
Stabilization frame thrusters fire	0.576
Frame trips recovery aneroid	0.582
Frame trips oxygen system	0.591
Frame completes rotation	0.633
Rocket burns out	0.924
Recovery	
Recovery chute deploys	3.232
Recovery chute lines stretch	4.232
Recovery chute disreefs	6.832
Recovery chute anchor releases	10.232
Capsule repositions	11.232
Stabilization frame repositions	11.532
Flotation booms project	12.632





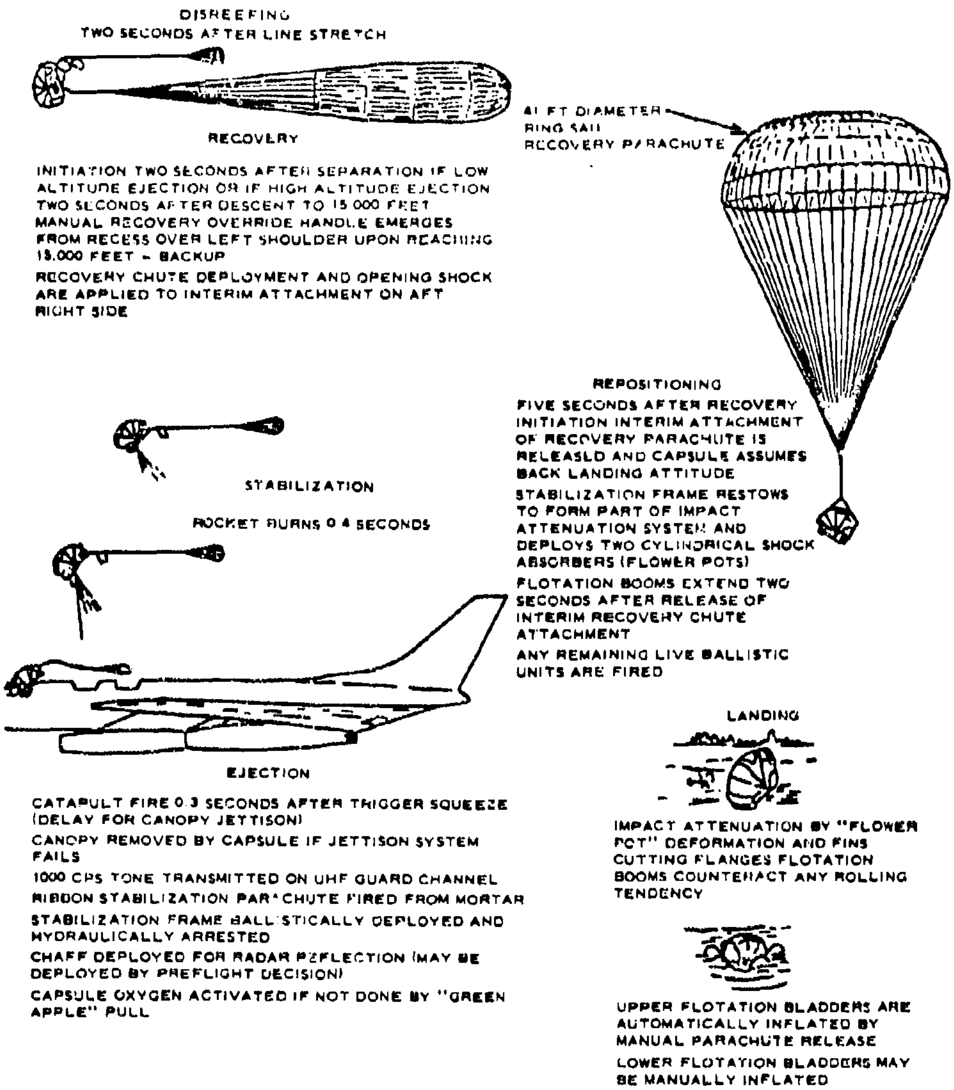
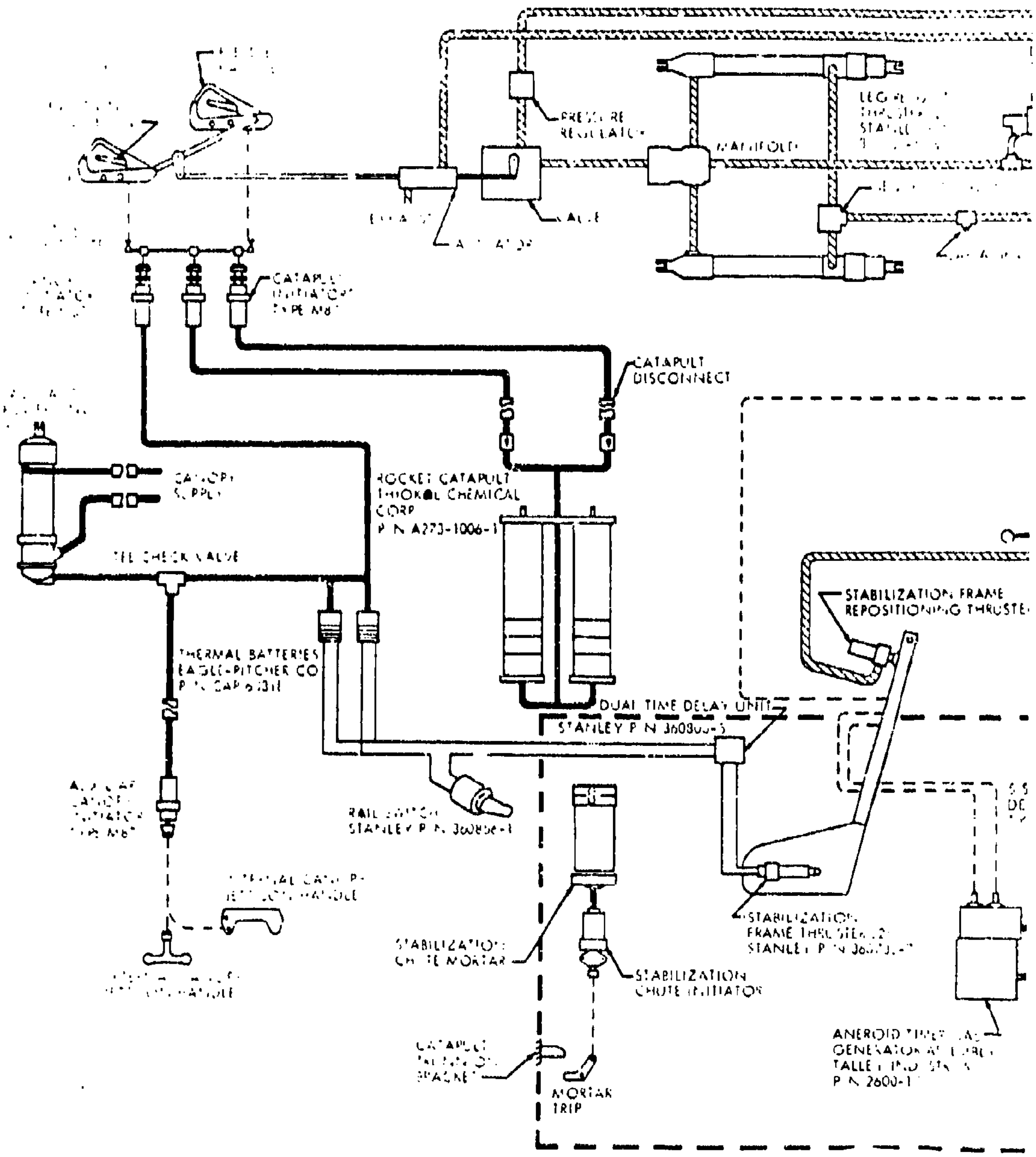


Figure 122. Stanley B-58 Encapsulated Seat – Ejection and Recovery Sequence


PRESSURE REGULATOR
MANIFOLD
VALVE
CATAPULT INITIATORS TYPE M87
CATAPULT DISCONNECT
CANOPY SUPPLY
TEE CHECK VALVE
ROCKET CATAPULT THIOKOL CHEMICAL CORP P/N A273-1006-1
THERMAL BATTERIES EAGLE-PITCHER CO
DUAL TIME DELAY UNIT
STABILIZATION FRAME REPOSITIONING THRUSTER
RAIL SWITCH
STABILIZATION CHUTE MORTAR
STABILIZATION CHUTE INITIATOR
STABILIZATION FRAME THRUSTERS
MORTAR TRIP

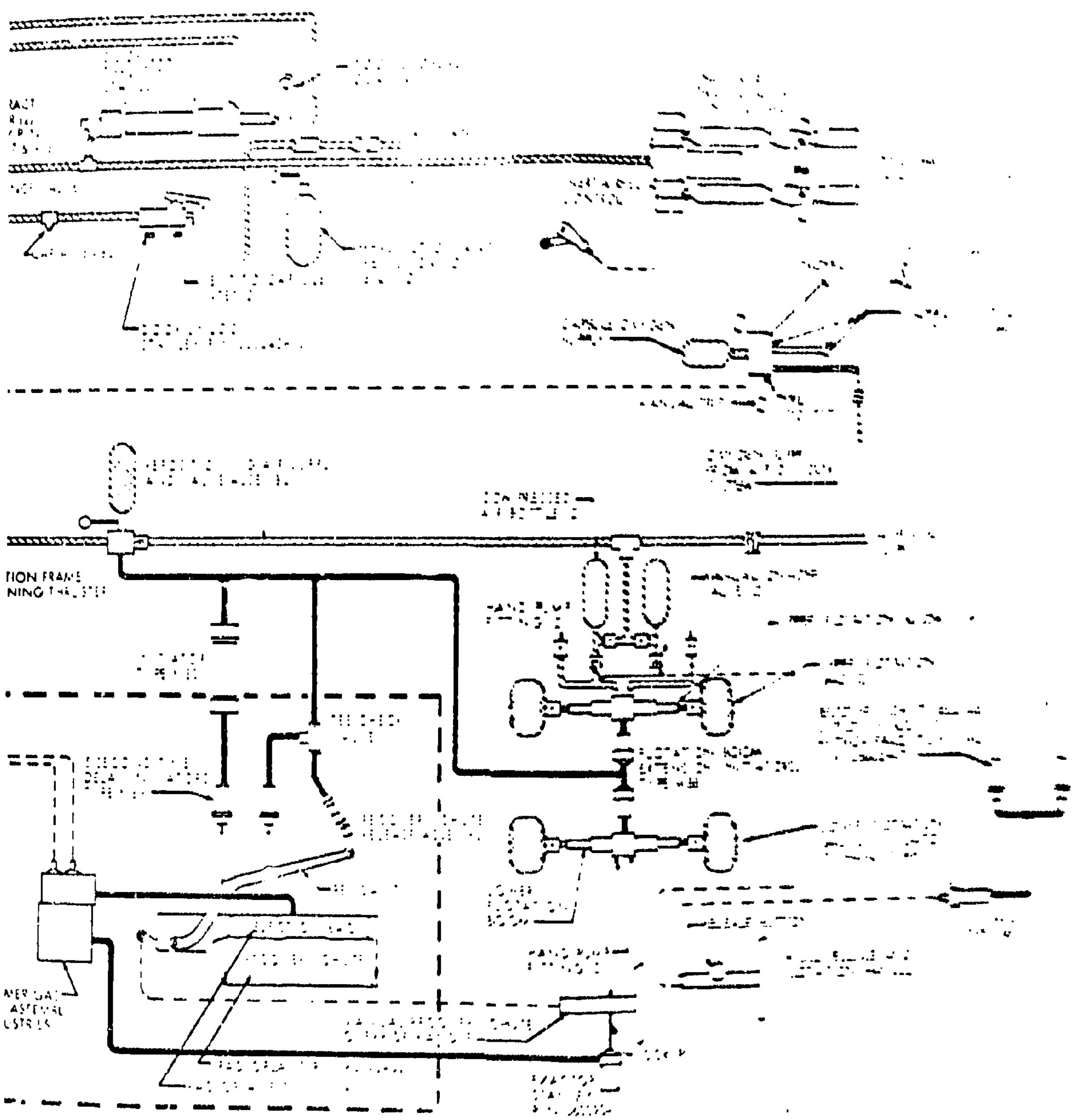


Figure [illegible]

Accelerations of the capsule reach a maximum of approximately 29 g in a transverse direction and approximately 25 g in a lateral direction at 700 KEAS. The nominal spinal accelerations imposed on a 50th percentile man by the catapult are approximately 13 g, which will vary depending upon temperature, batch tolerance, and weight of the man.

The capsule escape trajectory relative to the ground during a low-speed test at Edwards Air Force Base is shown in Fig. 124. The capsule escape trajectories relative to the aircraft during tests at Edwards Air Force Base and Hurricane Mesa, Utah, for low, intermediate, and high speeds are shown in Figs. 125, 126, and 127.

Table XXVI gives the seat weight breakdown.

Table XXVI. Stanley B-58 Encapsulated Seat Weight Breakdown

Item		Weight (Pounds)
"Bare" seat		150.5
Structural less chute and stick boxes	81.8	
System plumbing	6.0	
Seat, actuator and inertia reel	30.0	
Wiring	6.5	
Miscellaneous paint, glue and filler	5.0	
Disconnect	3.2	
Catapult	18.0	
Door installation and curtain		36.5
Door installation	63.0	
Curtain installation	3.5	
Survival gear and attachments		52.6
Preejection system		14.4
Preejection plumbing and ballistics	7.9	
Leg retraction	6.5	
Recovery parachute and box		45.3
Recovery parachute and bag	30.0	
Recovery parachute box	15.3	
Recovery system		51.1
Impact attenuators	8.0	
Plumbing and ballistics	14.9	
Manual override controls and gas generator	11.3	
Miscellaneous	16.0	
Stabilization system (frame and parachute)		48.1
Flotation system (booms and inflation system)		10.3
Oxygen, pressurization and relief valve		13.1
Rocket		40.7
Canopy actuator, stick, stick box and manual overrides		13.6
Canopy actuator	5.5	
Stick	3.2	
Stick box structure	3.3	
Manual overrides	1.6	
Crewman (less personal equipment)		200.0
Total		706.2

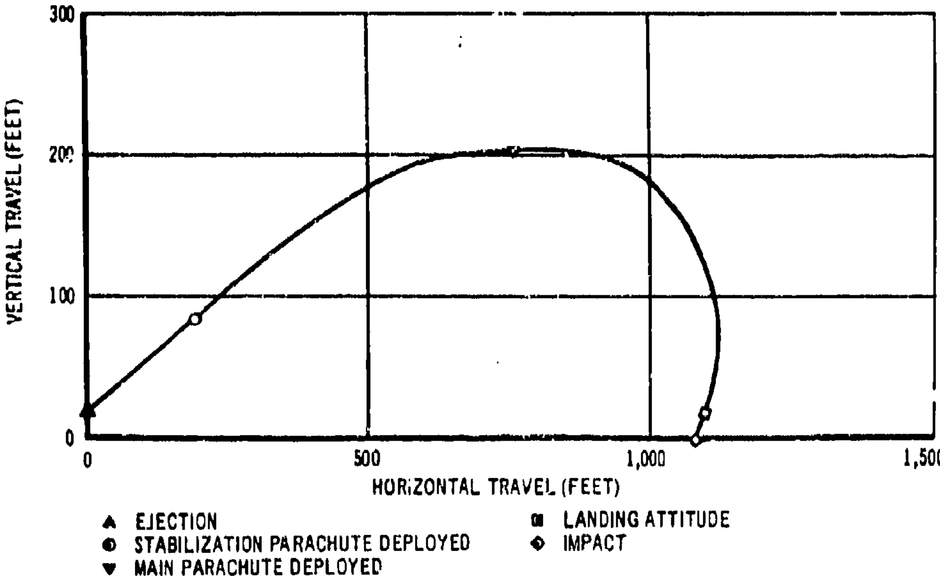


Figure 124. Stanley B-58 Encapsulated Seat – Capsule Escape Trajectory Relative to Ground. Ejection No. 1 at 106 KEAS – EAFB Test B-58 No. 2

d. STANLEY TWO-PLACE ENCAPSULATED SEAT

The Stanley two-place encapsulated seat is a further development of the B-58 capsule for strike/intercept aircraft application. Wind tunnel tests were conducted at the University of Colorado and the U.S. Air Force Academy subsonic wind tunnels. The tests at the University of Colorado were made primarily to investigate the yawing and pitching moment characteristics of the capsule body. A configuration study was conducted at the Air Force Academy facility where all six aerodynamic forces and moments were measured.

This escape capsule may be briefly described as the minimum sized modular escape system that will encapsulate two people plus a center console and a boom stabilized vehicle that is boosted by both catapult and rocket. Provisions are made for safe escape for two crewmen at speeds between zero and 300 KEAS at ground level and up to Mach 1.25 at near ground level. Escape is also provided up to Mach 3.0 at altitudes between 42,000 feet and 80,000 feet. The escape system design capability is shown in Fig. 128. The installation envelope of the two-place encapsulated seat is shown in Fig. 129 and the interior arrangement is shown in Fig. 130.

Pre-ejection functions are electrically initiated by pulling the ejection handle. This actuates the torso-retracting, leg-positioning, and door-closing systems. The crewmen are driven back against the seats with their heads in the headrests. Their legs are raised, and their feet are drawn back into the capsule. The capsule doors are then closed to provide a pressurized compartment equivalent to an altitude of 37,500 feet. At this point, the crewman may

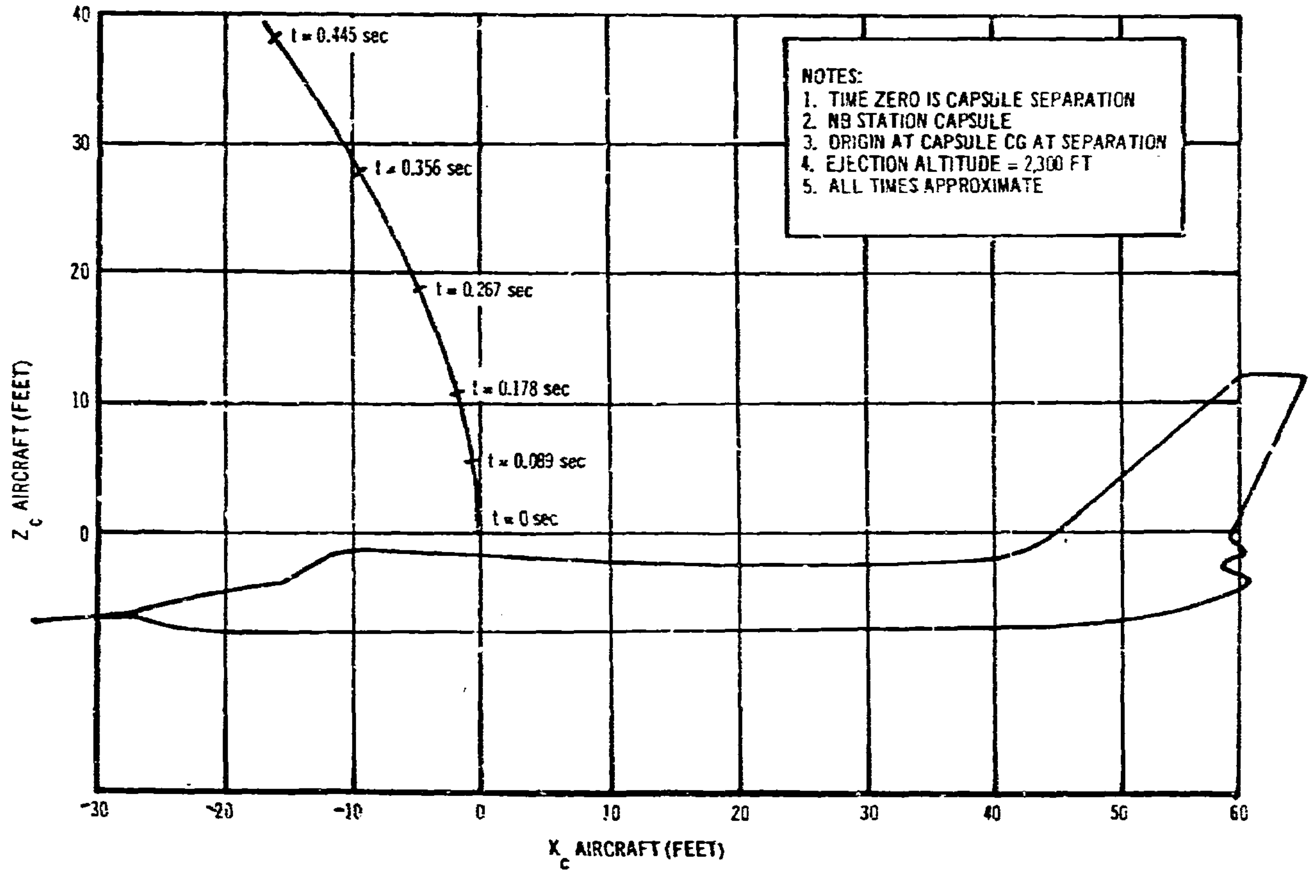


Figure 125. Stanley B-58 Encapsulated Seat – Escape Trajectory Relative to Aircraft EAFB Test B-58 No. 2 – Ejection No. 1 at 106 KEAS

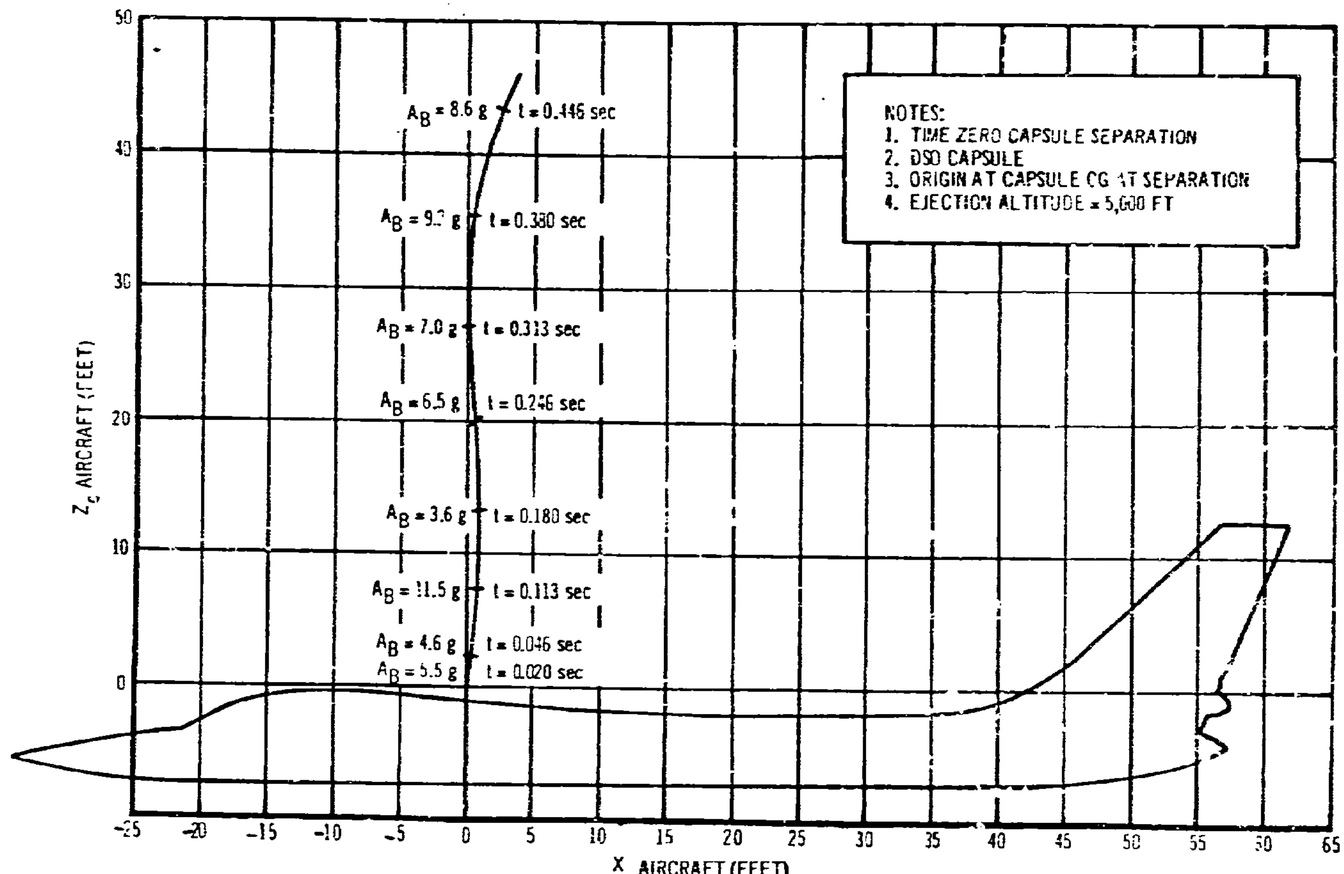


Figure 126. Stanley B-58 Encapsulated Seat – Escape Trajectory Relative to Aircraft. HSRS Test 29 at 443 KEAS

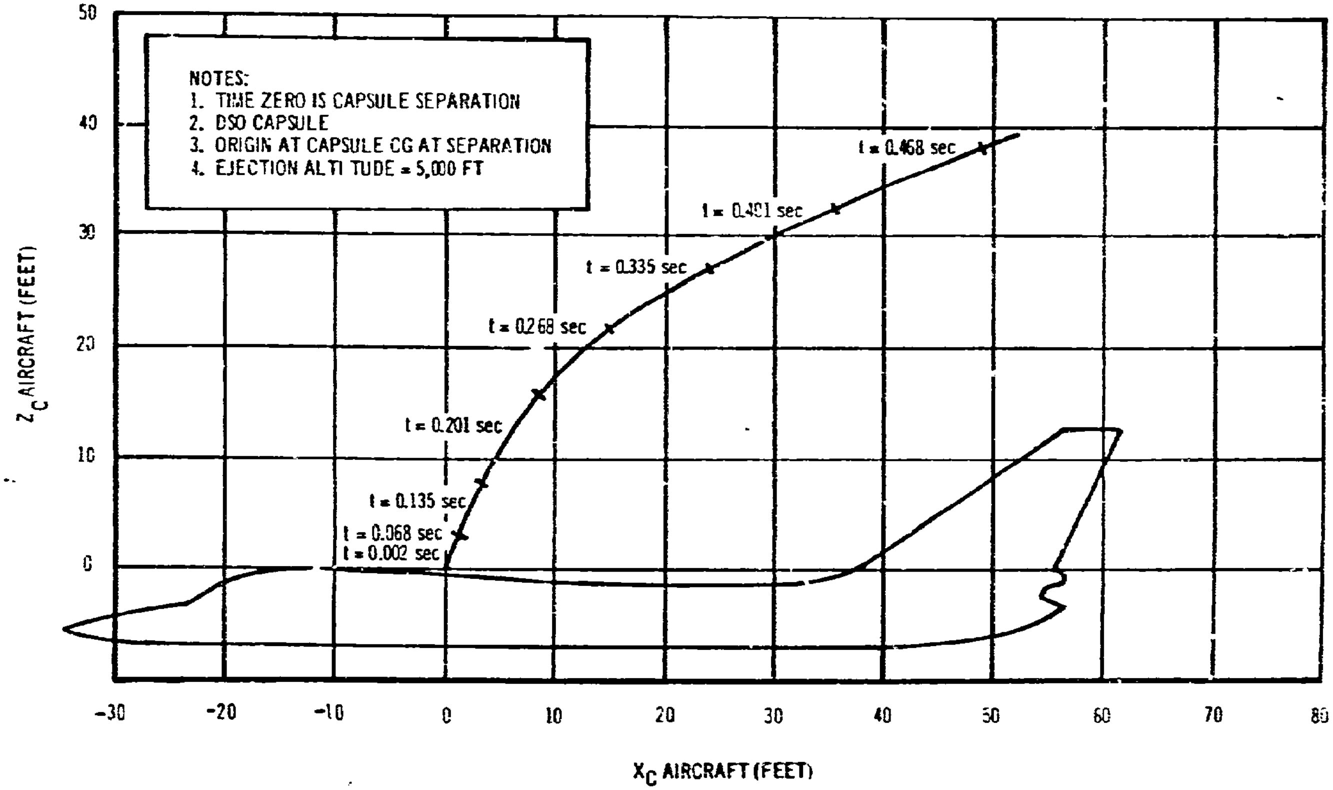


Figure 127. Stanley B-58 Encapsulated Seat – Escape Trajectory Relative to Aircraft. HSRS Test 40 at 669 KEAS – Rear Occupant

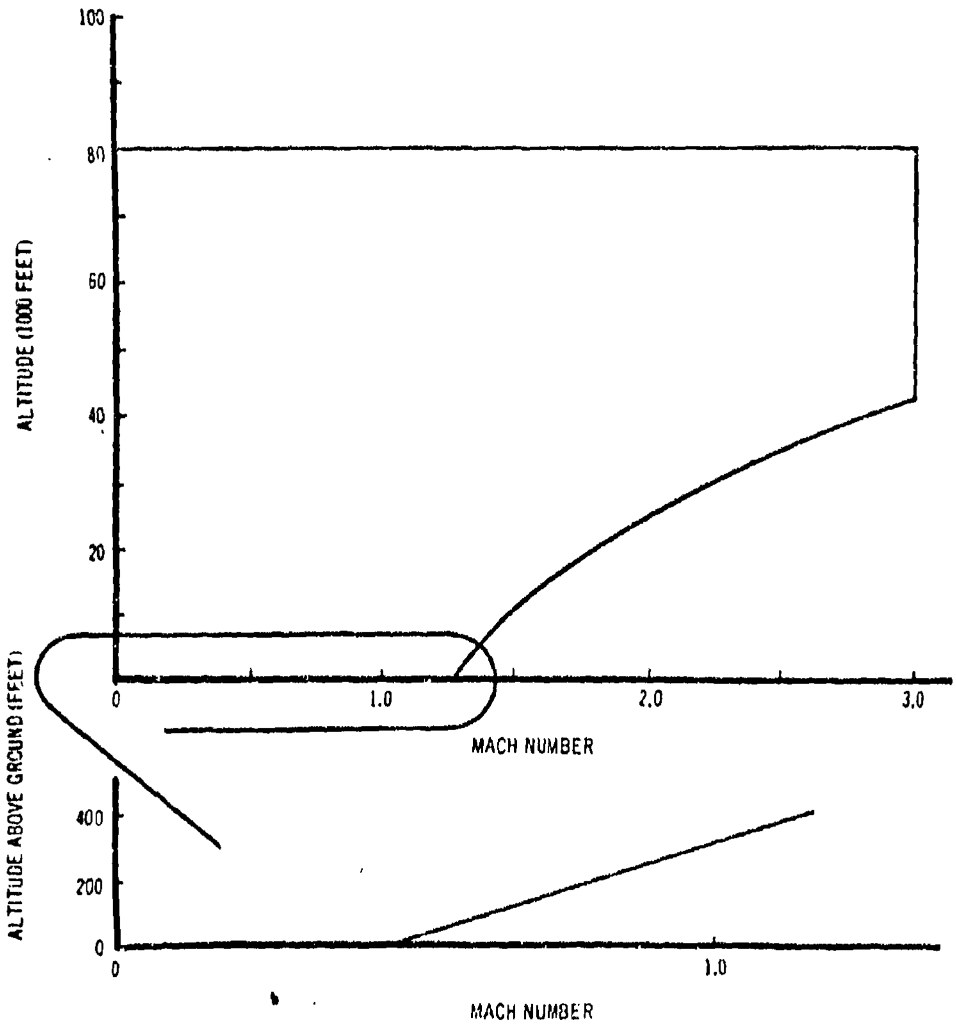
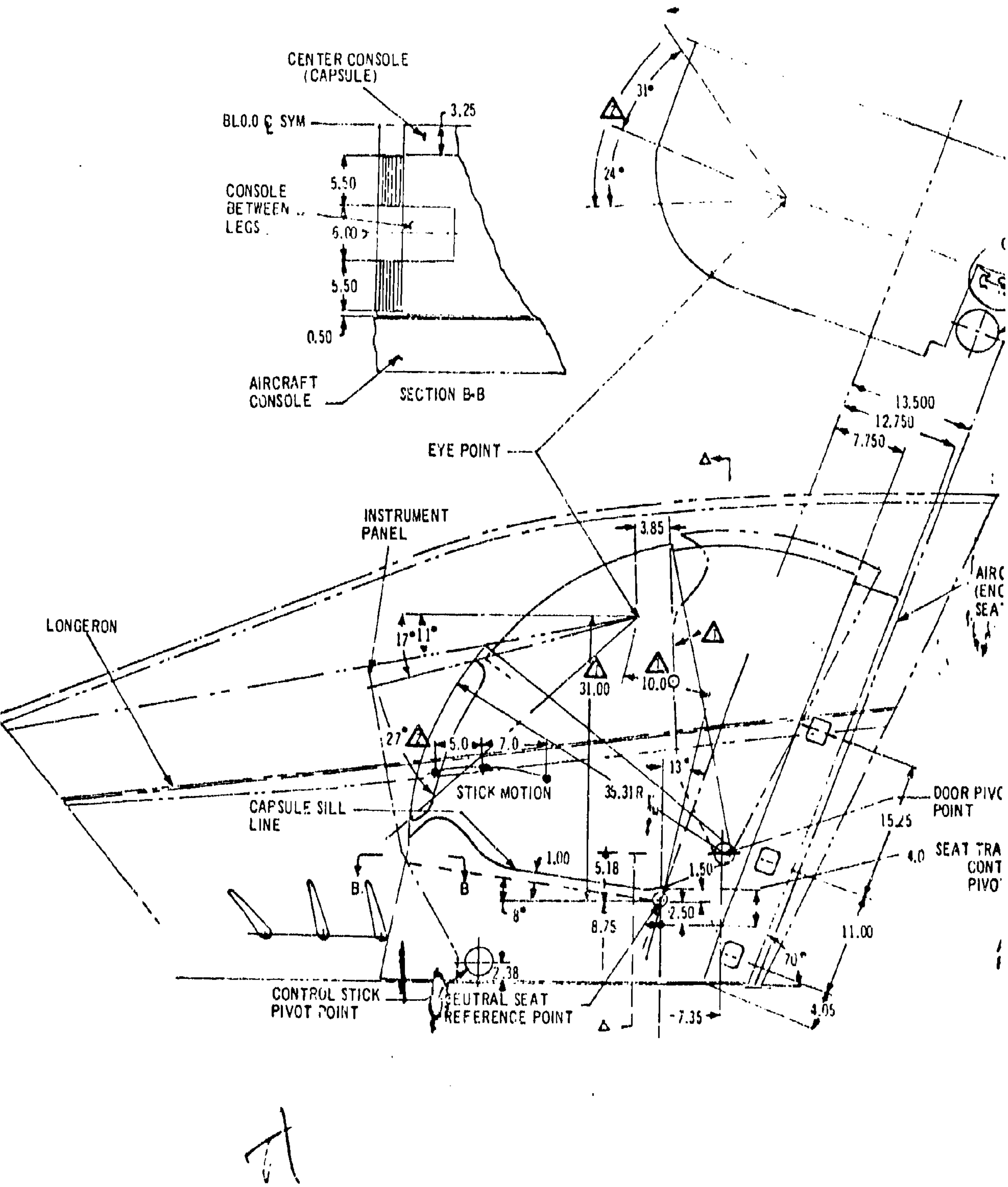


Figure 128. Stanley Two-Place Encapsulated Seat – Escape System Performance Capability



CENTER CONSOLE
(CAPSULE)
BL0.0 ℄ SYM
3.25
5.50
CONSOLE
BETWEEN
LEGS
6.00
5.50
0.50
AIRCRAFT
CONSOLE
SECTION B-B
31°
24°
13.500
12.750
7.750
EYE POINT
INSTRUMENT
PANEL
3.85
LONGERON
17°
11°
31.00
10.00
27°
5.0
7.0
13°
STICK MOTION
35.31R
CAPSULE SILL
LINE
DOOR PIVC
POINT
15.25
1.00
5.18
1.50
4.0
SEAT TRA
CONT
PIVO
B
B
8°
2.50
8.75
11.00
70°
2.38
CONTROL STICK
PIVOT POINT
NEUTRAL SEAT
REFERENCE POINT
7.35
4.05

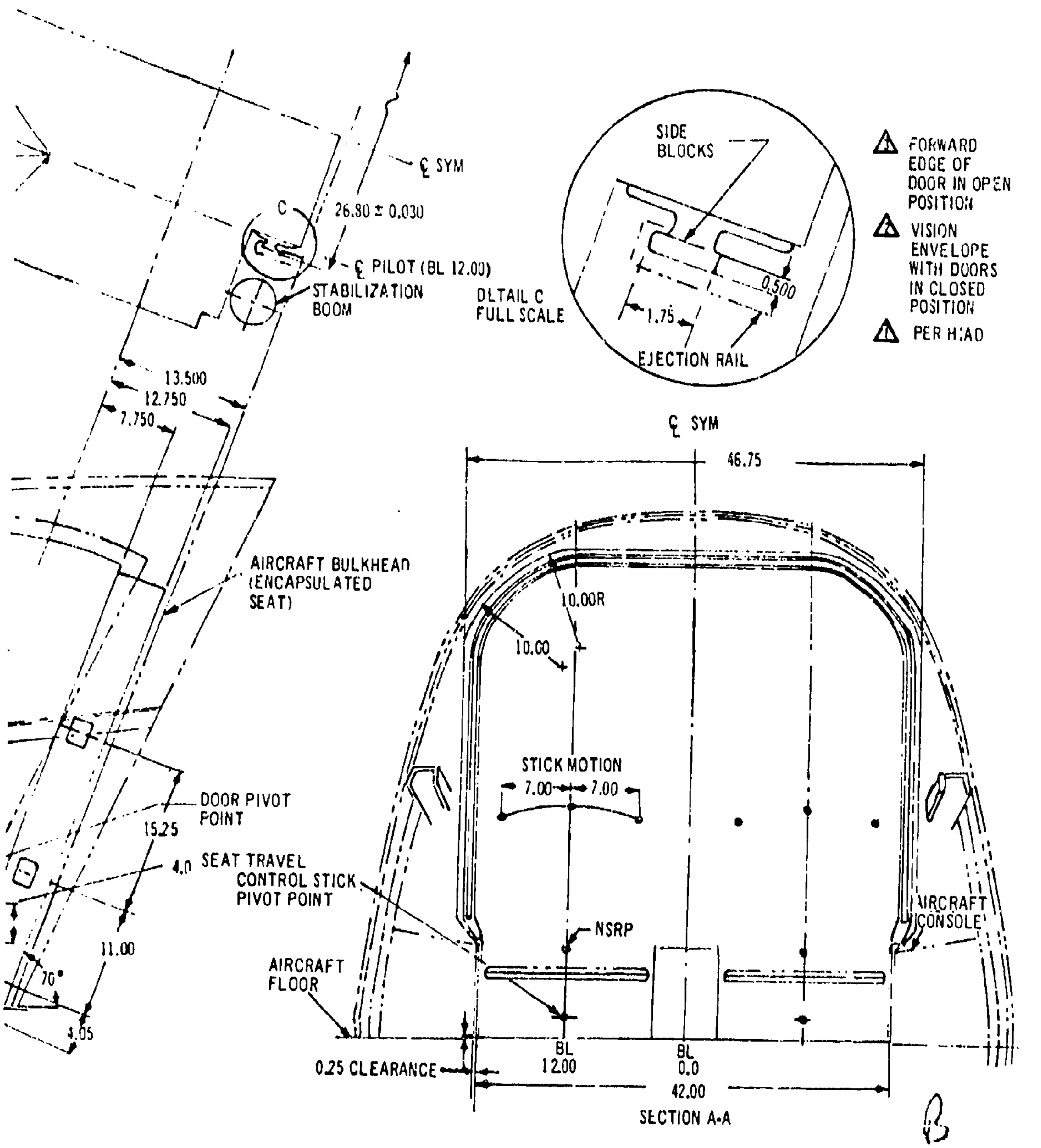


Figure 129. Stanley Two-Place Encapsulated Seat – Envelope

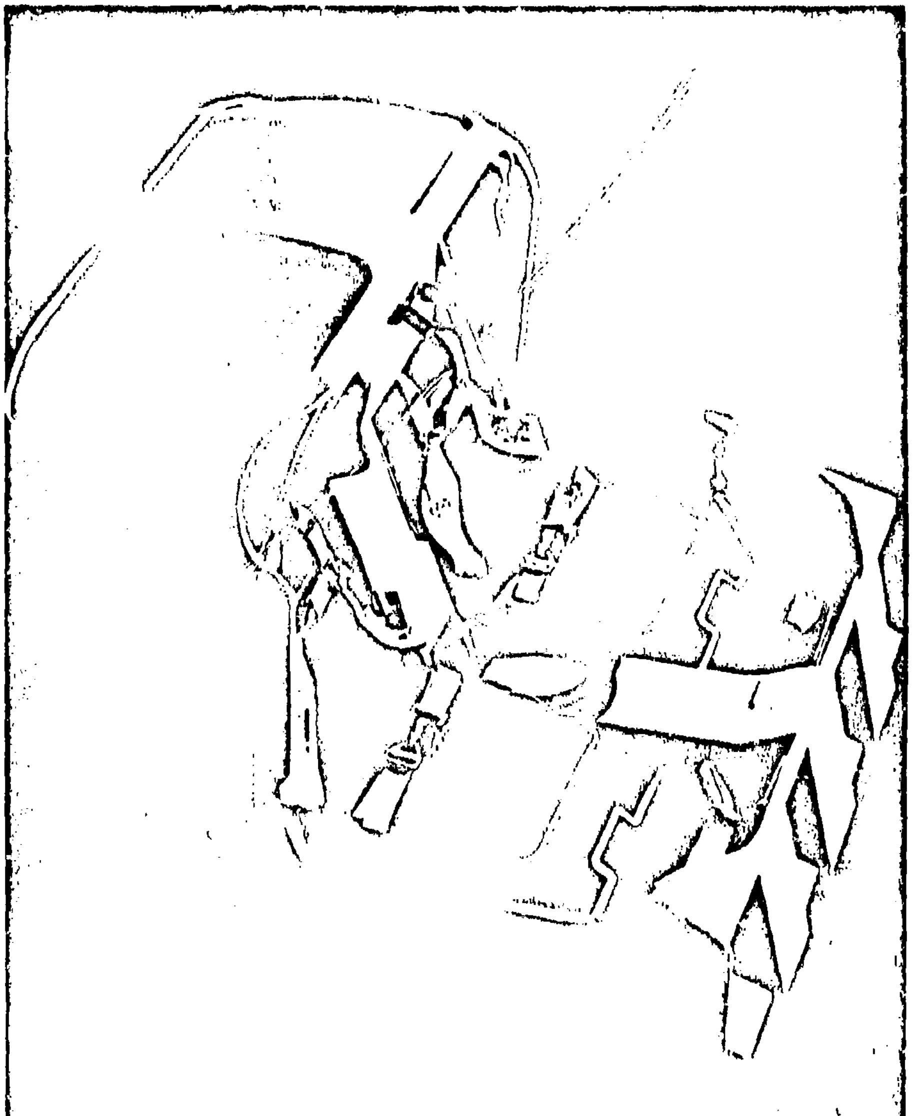


Figure 130. Stanley Two-Place Encapsulated Seat – Interior Arrangement

choose to abandon the aircraft or, if the capsule was closed for emergency pressurization only, the airplane can be flown to a lower altitude, the capsule can be reopened, and the flight can continue. Should a subsequent emergency arise, the capsule can be reclosed, repressurized, and ejected from the aircraft.

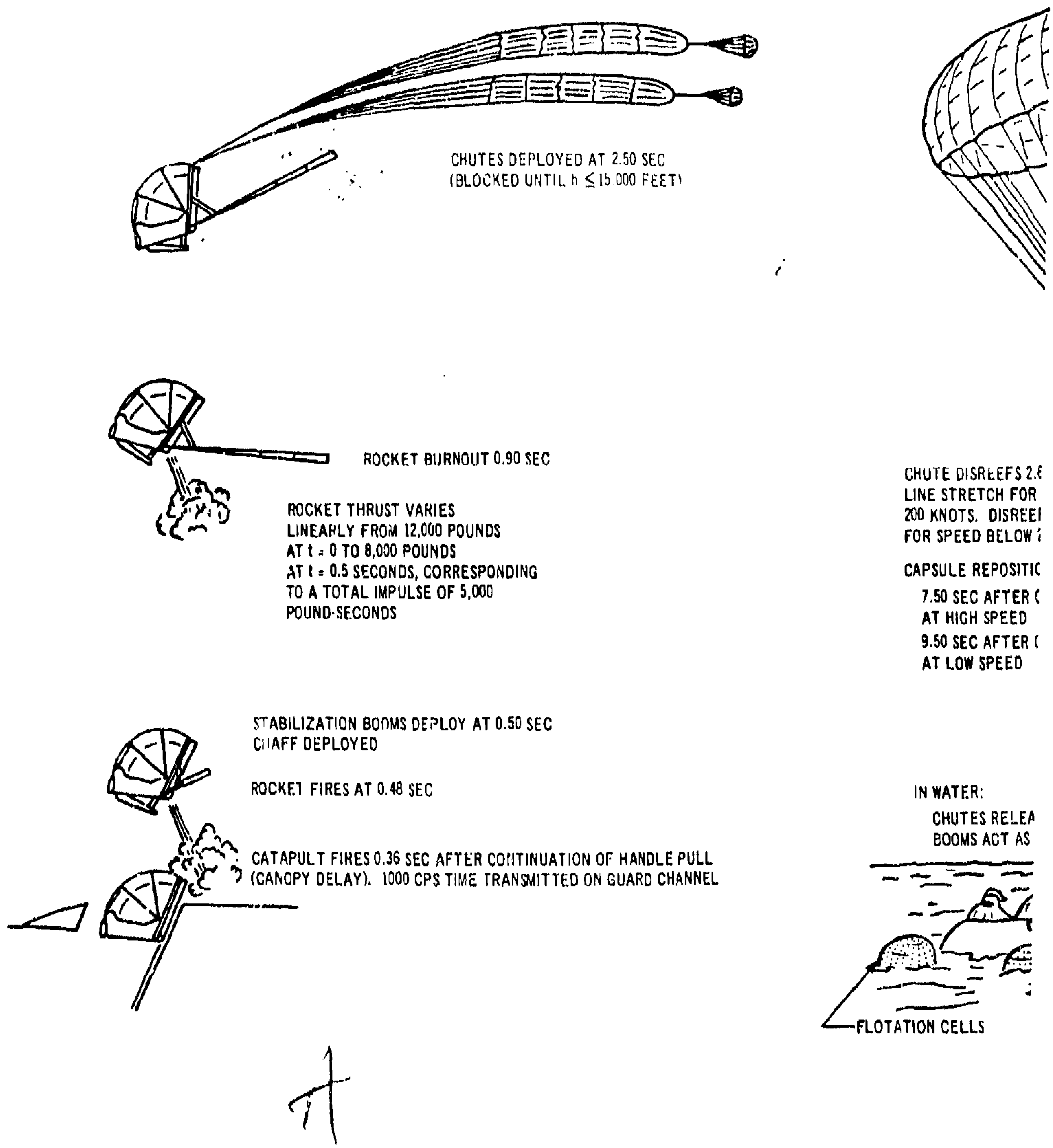
When ejection is necessary, it is initiated by rotating the ejection T-handle 90 degrees in either direction and then pulling. The first action initiates removal of the canopy. A ballistic time delay is built into the catapult to permit canopy removal prior to capsule ejection. In case of malfunction of the canopy actuator, the power of the catapult can be used to remove the canopy.

The sequence of events during ejection, stabilization, recovery, and landing are shown in Fig. 131. The operation sequence times are summarized in Table XXVII. A schematic diagram of the escape system is shown in Fig. 132.

The capsule attitude for ground landing is with the occupant's back at about 30 degrees to the horizontal (head up). Landing shock is absorbed by the stabilization booms in bending and shearing of metal in the landing gear support struts. The landing skid allows the capsule to skid in any direction during a crosswind landing. Water landing is the same as ground landing except the shock attenuation system does not operate due to the low forces involved. The capsule will float by itself. Water-filled stabilization booms will provide flotation stability for the capsule in its normal backdown flotation attitude. A flotation system consisting of four flotation bags is provided as a backup to ensure flotation capabilities of the capsule itself.

Accelerations along the capsule X and Z axes and angle of attack computed for the first 0.6 second after separation of the capsule from the aircraft are shown in Figs. 133 and 134.

Trajectory and velocity curves for the two-place encapsulated seat during a zero-zero ejection are shown in Fig. 135. Computed trajectories of the capsule relative to the aircraft under various conditions of speed and altitude are shown in Fig. 136.



CHUTES DEPLOYED AT 2.50 SEC
(BLOCKED UNTIL h ≤ 15,000 FEET)
ROCKET BURNOUT 0.90 SEC
ROCKET THRUST VARIES
LINEARLY FROM 12,000 POUNDS
AT t = 0 TO 8,000 POUNDS
AT t = 0.5 SECONDS, CORRESPONDING
TO A TOTAL IMPULSE OF 5,000
POUND-SECONDS
CHUTE DISREEFS 2.
LINE STRETCH FOR
200 KNOTS. DISREE
FOR SPEED BELOW
CAPSULE REPOSITIC
7.50 SEC AFTER
AT HIGH SPEED
9.50 SEC AFTER
AT LOW SPEED
STABILIZATION BOOMS DEPLOY AT 0.50 SEC
CHAFF DEPLOYED
ROCKET FIRES AT 0.48 SEC
CATAPULT FIRES 0.36 SEC AFTER CONTINUATION OF HANDLE PULL
(CANOPY DELAY). 1000 CPS TIME TRANSMITTED ON GUARD CHANNEL
IN WATER:
CHUTES RELEA
BOOMS ACT AS
FLOTATION CELLS

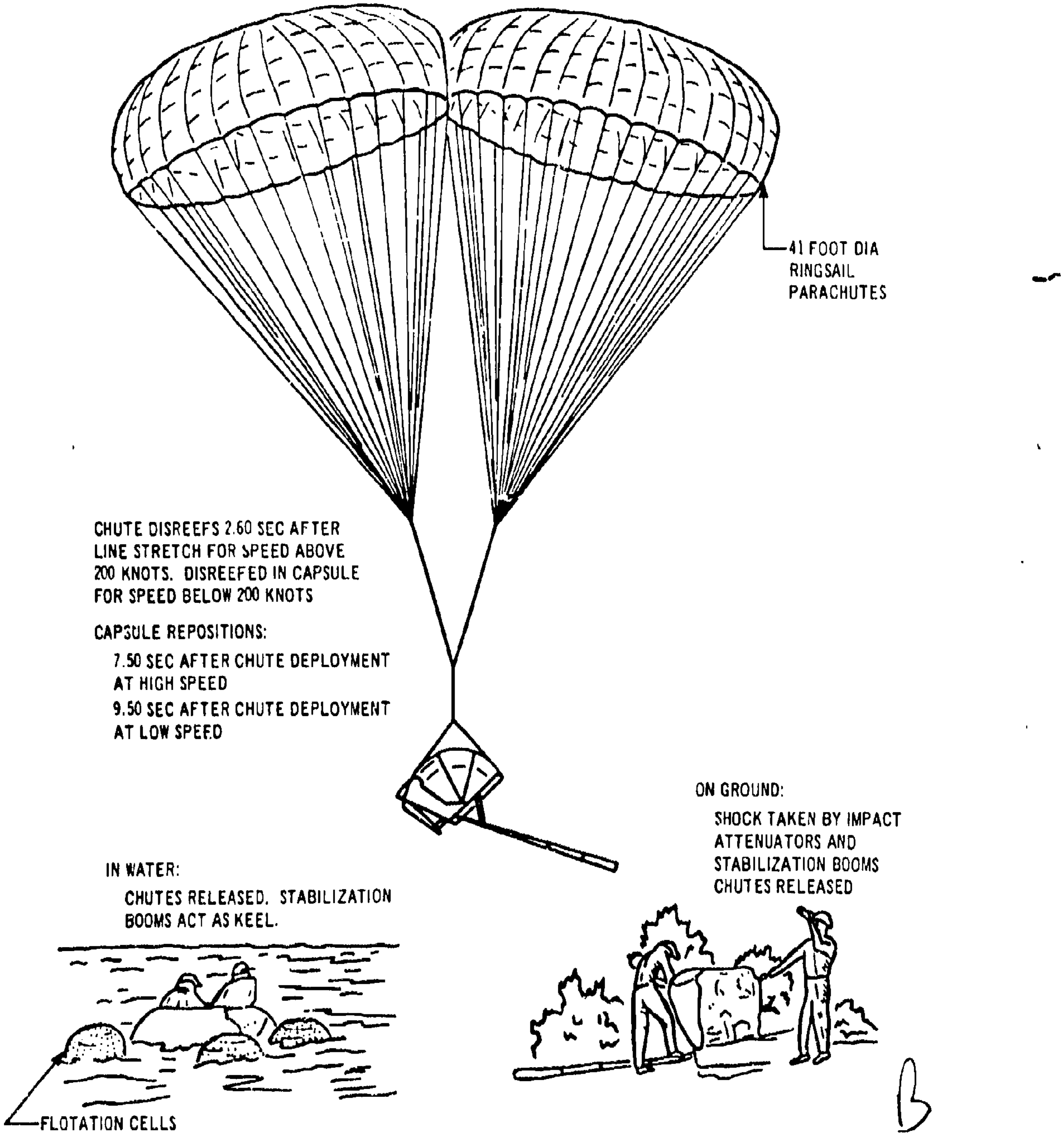
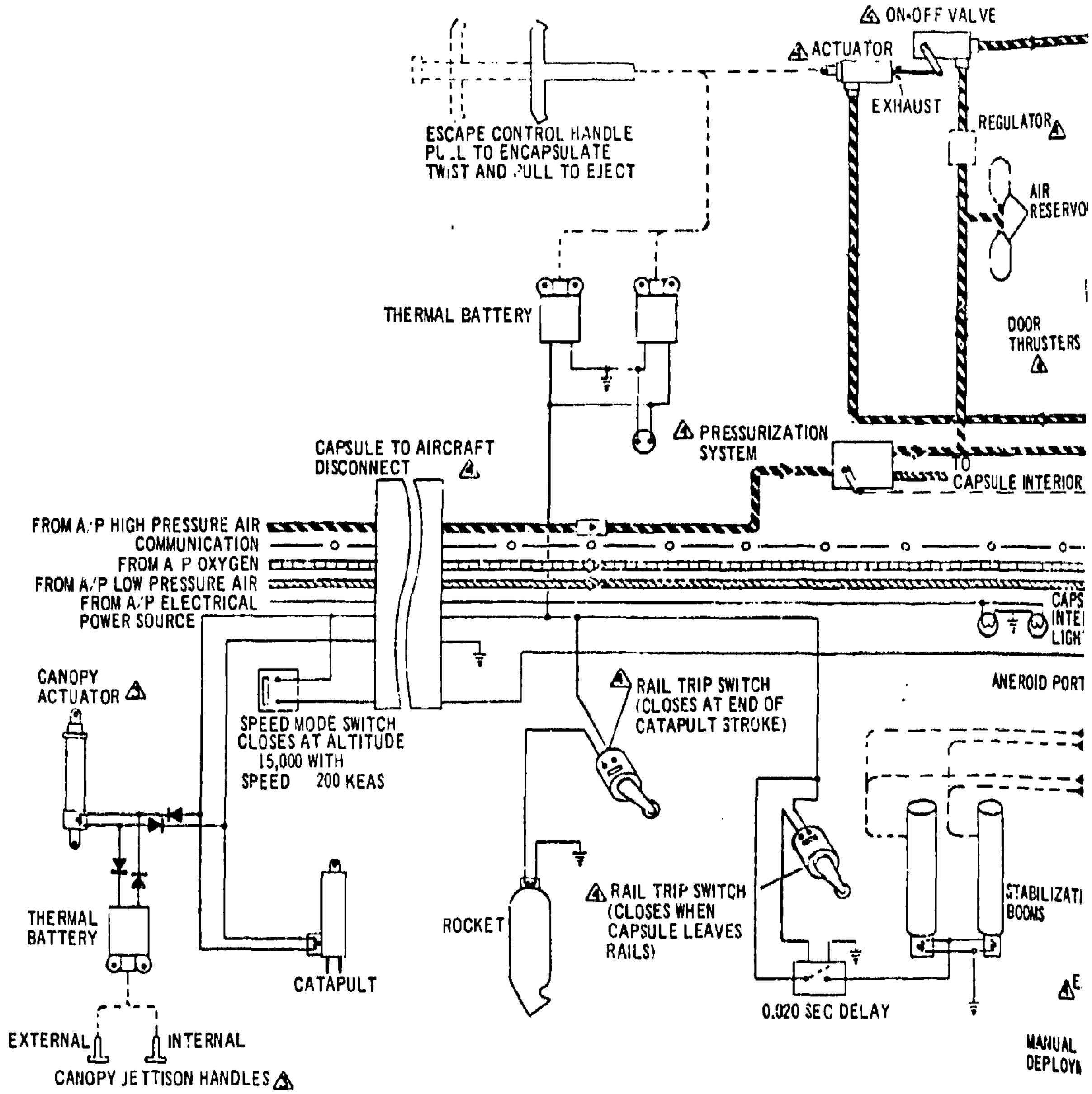
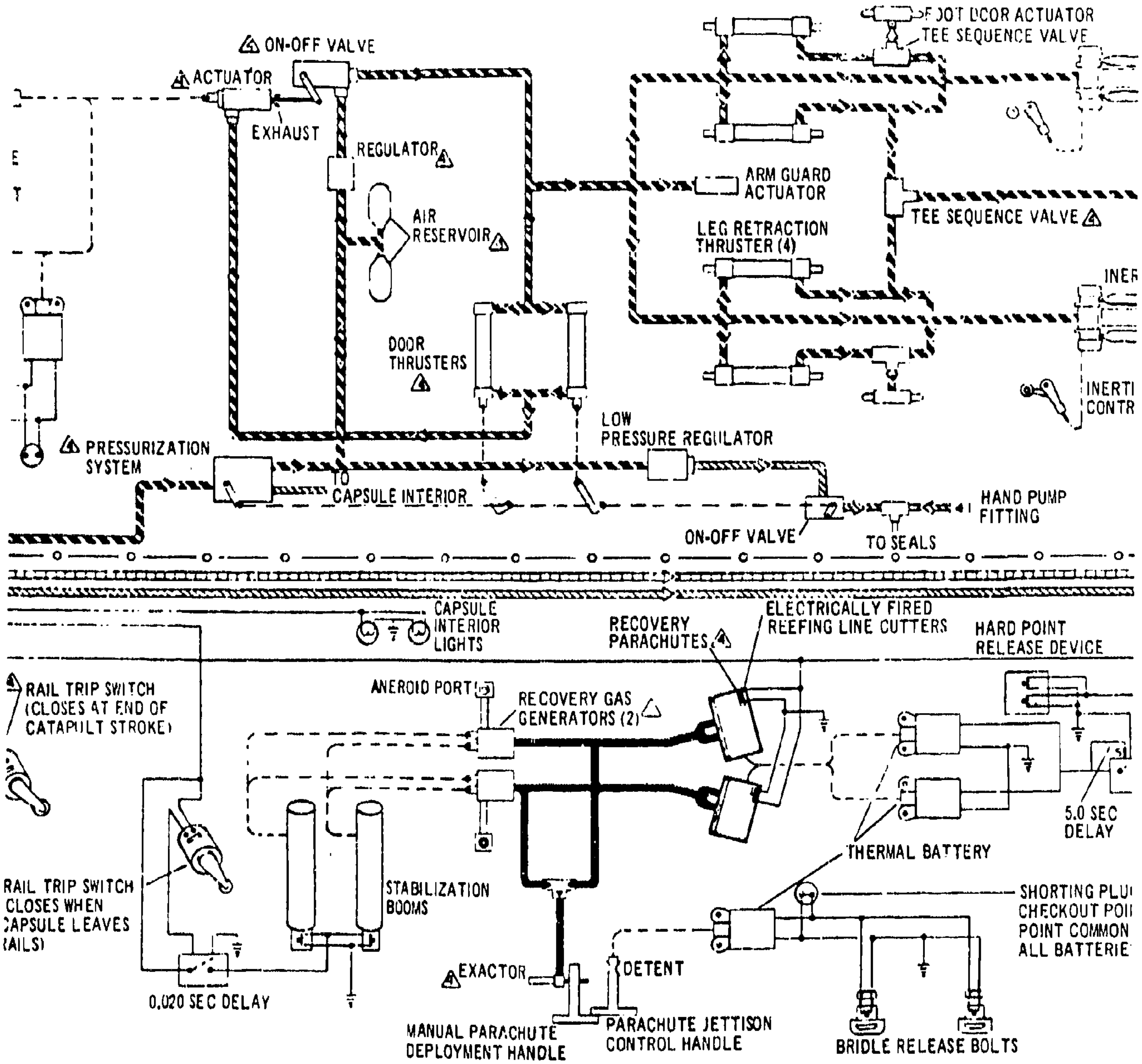
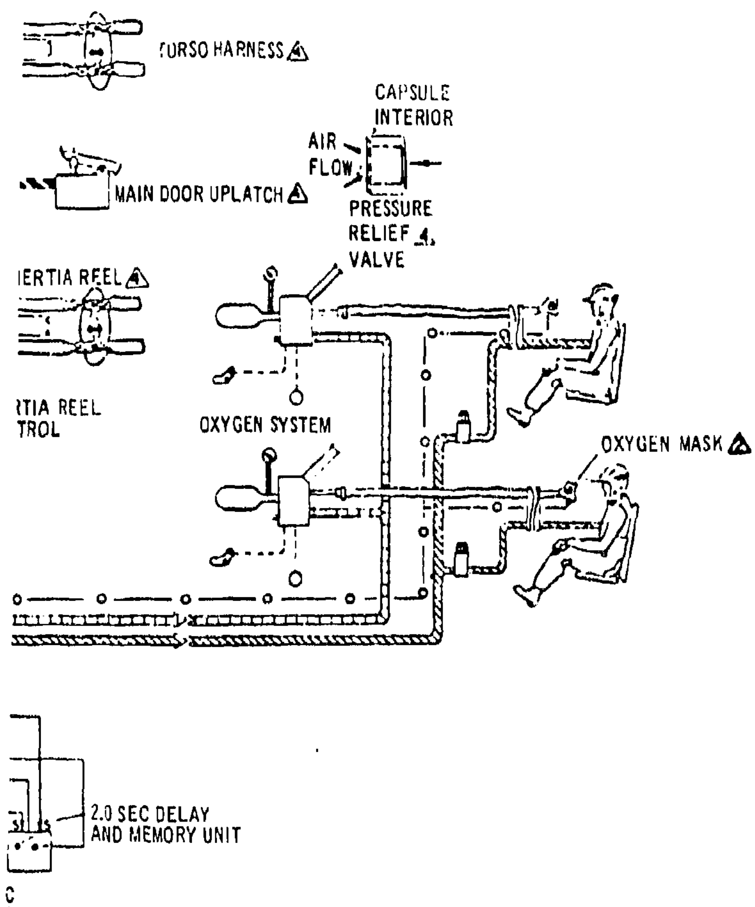


Figure 131. Stanley Two-Place Encapsulated Seat – Ejection, Stabilization, Recovery, and Landing


ON-OFF VALVE
ACTUATOR
EXHAUST
REGULATOR
AIR
RESERVO
ESCAPE CONTROL HANDLE
PULL TO ENCAPSULATE
TWIST AND PULL TO EJECT
THERMAL BATTERY
DOOR
THRUSTERS
PRESSURIZATION
SYSTEM
TO
CAPSULE INTERIOR
CAPSULE TO AIRCRAFT
DISCONNECT
FROM A/P HIGH PRESSURE AIR
COMMUNICATION
FROM A/P OXYGEN
FROM A/P LOW PRESSURE AIR
FROM A/P ELECTRICAL
POWER SOURCE
CANOPY
ACTUATOR
ANEROID PORT
SPEED MODE SWITCH
CLOSES AT ALTITUDE
15,000 WITH
SPEED 200 KEAS
RAIL TRIP SWITCH
(CLOSES AT END OF
CATAPULT STROKE)
THERMAL
BATTERY
ROCKET
RAIL TRIP SWITCH
(CLOSES WHEN
CAPSULE LEAVES
RAILS)
STABILIZATI
BOOMS
CATAPULT
0.020 SEC DELAY
EXTERNAL
INTERNAL
CANOPY JETTISON HANDLES
MANUAL
DEPLOY



ON-OFF VALVE
ACTUATOR
EXHAUST
REGULATOR
AIR RESERVOIR
DOOR THRUSTERS
PRESSURIZATION SYSTEM
TO CAPSULE INTERIOR
LOW PRESSURE REGULATOR
ON-OFF VALVE
TO SEALS
HAND PUMP FITTING
TEE SEQUENCE VALVE
ARM GUARD ACTUATOR
TEE SEQUENCE VALVE
LEG RETRACTION THRUSTER (4)
CAPSULE INTERIOR LIGHTS
RECOVERY PARACHUTES
ELECTRICALLY FIRED REEFING LINE CUTTERS
HARD POINT RELEASE DEVICE
RAIL TRIP SWITCH (CLOSES AT END OF CATAPULT STROKE)
ANEROID PORT
RECOVERY GAS GENERATORS (2)
5.0 SEC DELAY
THERMAL BATTERY
RAIL TRIP SWITCH CLOSES WHEN CAPSULE LEAVES RAILS)
STABILIZATION BOOMS
EXACTOR
DETENT
0.020 SEC DELAY
MANUAL PARACHUTE DEPLOYMENT HANDLE
PARACHUTE JETTISON CONTROL HANDLE
BRIDLE RELEASE BOLTS



LEGEND

- POWER CARTRIDGE (1 WATT, 1 AMP NO FIRE)
- GROUND
- DIODE (QUADE)
- SIGNAL INPUT
- CHECK VALVE
- COMMUNICATION LINE
- ELECTRICAL LINE (A/P SUPPLY)
- ELECTRICAL LINE (CAPSULE SUPPLY)
- MECHANICAL CONNECTION
- BALLISTIC GAS
- OXYGEN
- LOW PRESSURE AIR
- HIGH PRESSURE AIR

△ ORIGINAL OR MODIFIED B-58 CAPSULE PARTS

△ CUSTOMER FURNISHED EQUIPMENT

△ GOVERNMENT FURNISHED EQUIPMENT

△ ALL CAPSULE ELECTRICAL CIRCUITS ARE COMPLETELY DUALIZED

C

Figure 132. Stanley Two-Place Encapsulated Seat – Escape Systems Schematic

Table XXVII. Stanley Two-Place Encapsulated Seat Operation Sequence Times

Below 15,000 Feet
Above 200 Knots

	Maximum Time (Seconds)
Pre-Ejection	
Handle pulled	0.0
Legs retract	0.6
Doors Close	1.0
Capsule pressurizes	7.0
Ejection	
Trigger pulled	0.00
Canopy jettisons	0.04
Catapult fires	0.36
Rocket fires	0.48
Capsule full emergency	0.49
Stab Boom deployment & Landing skid	0.50
Rocket burnout	0.90
Ejection	
Recovery chute deploys	2.50
Recovery chute line stretch	3.50
Recovery chute disreefs	6.1
Recovery chute anchor releases	8.5
Capsule reposition	10.0

Below 200 Knots

Recovery	
Recovery chute deploys (Disreefing in pack)	2.50
Recovery chute line stretch	3.50
Recovery chute filling	10.50
Capsule reposition	12.00

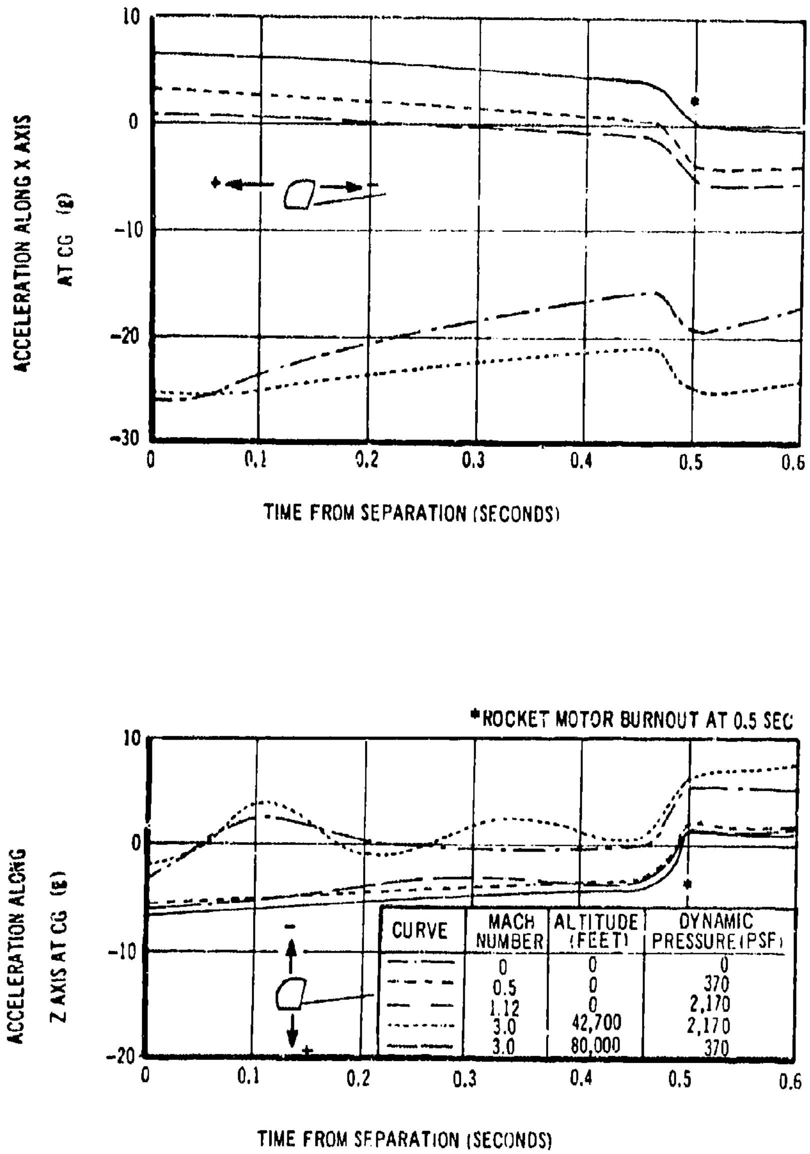


Figure 133. Stanley Two-Place Encapsulated Seat – Preliminary Acceleration Time History (Including Descent Phase)

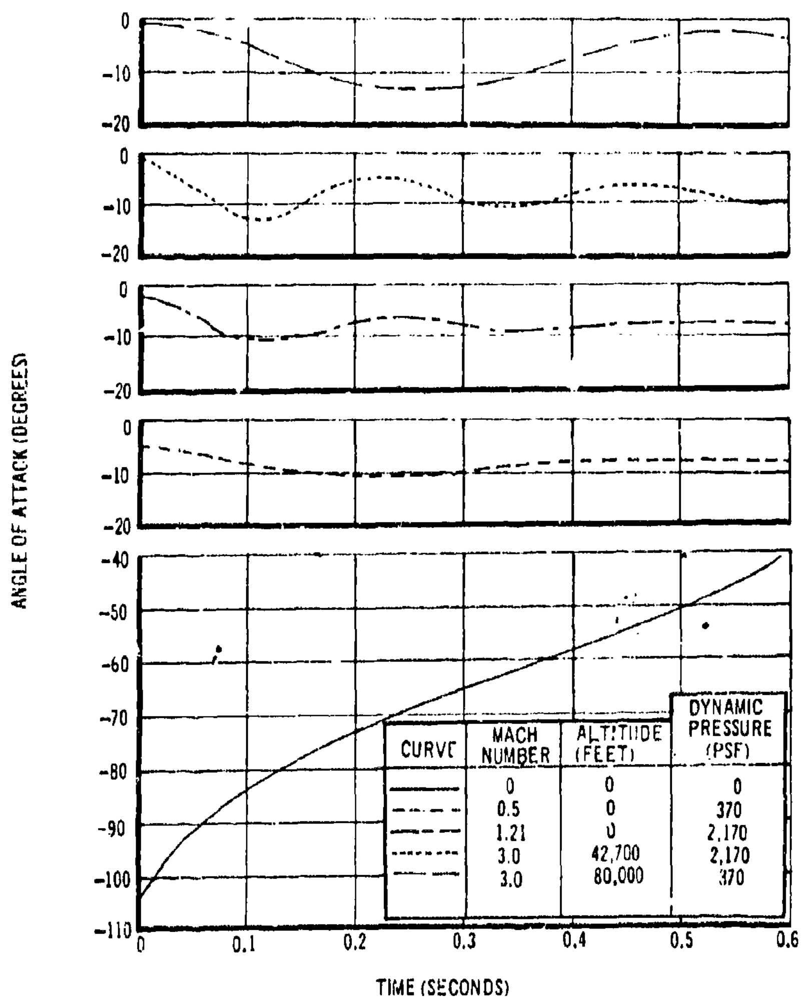


Figure 134. Stanley Two-Place Encapsulated Seat – Variations in Angle of Attack of Proposed Capsule Following Ejection

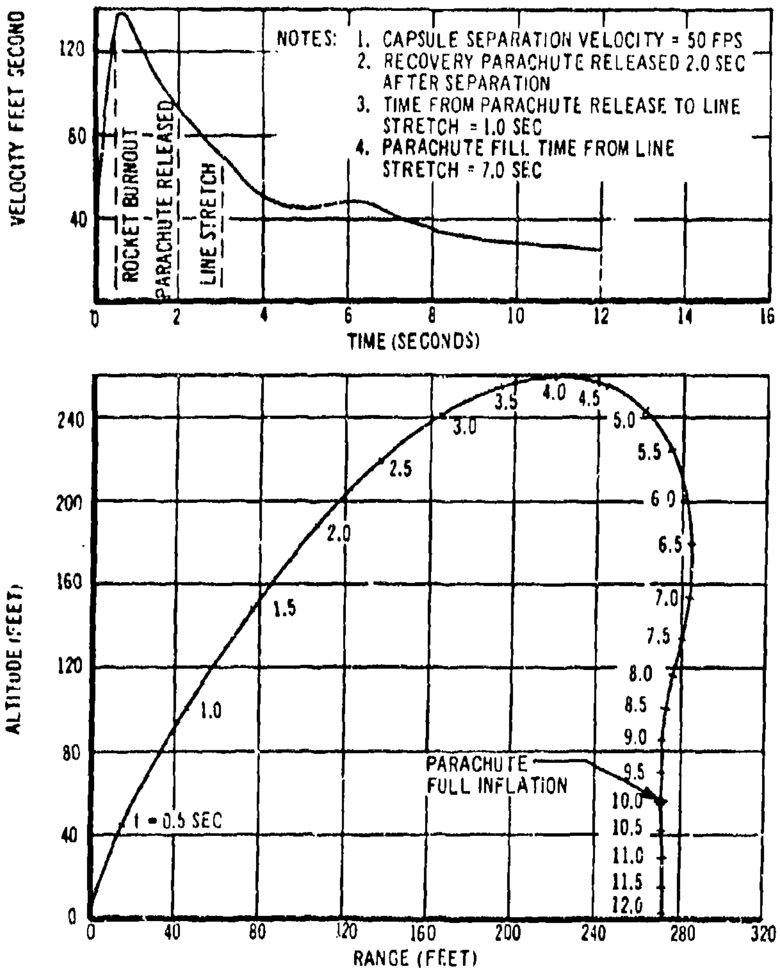


Figure 135. Stanley Two-Place Capsule Trajectory and Velocity History – 0-0 Ejection

CURVE	MACH NUMBER	ALTITUDE (FEET)	DYNAMIC PRESSURE
1	0	0	0
2	0.5	0	370
3	1.21	0	2,170
4	3.0	42,700	2,170
5	3.0	80,000	370

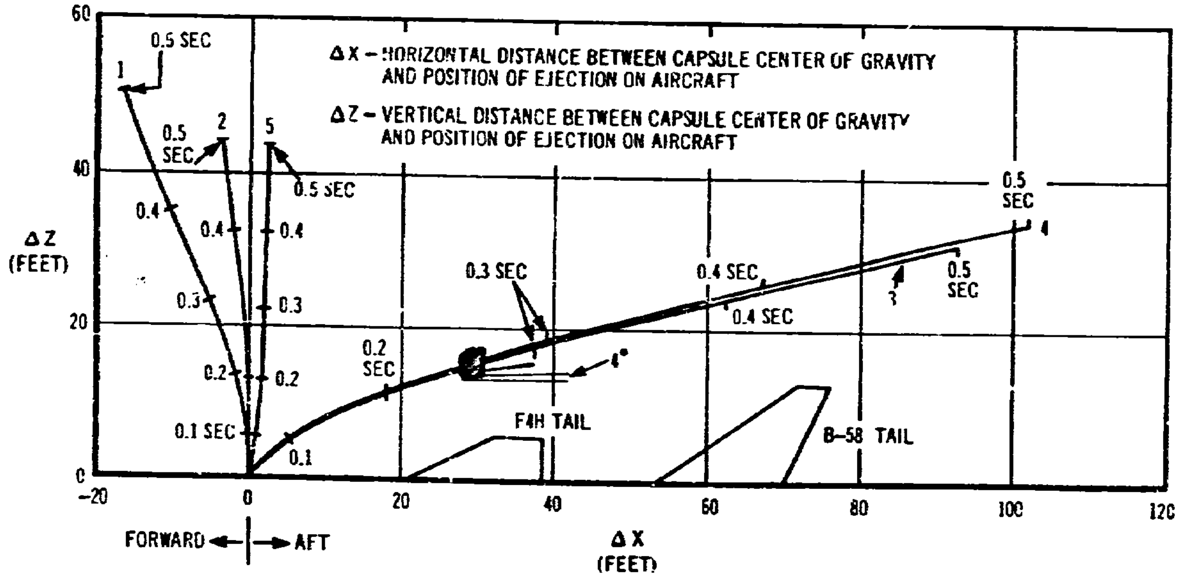


Figure 136. Stanley Two-Place Encapsulated Seat – Capsule Trajectory Relative to Aircraft

Table XXVIII gives the system weight breakdown.

Table XXVIII. Stanley Two-Place Encapsulated Seat Escape System Weight Breakdown

The following estimated weight is based on calculations made from preliminary design and stress data.

Item	Weight (Lb)
Basic structure	201.0
Seats and foot retraction mechanisms (2)	72.0
Doors, seals, and actuation mechanism	123.0
Console and capsule disconnect	25.0
Oxygen and pressurization systems	31.0
Encapsulation	13.0
Ejection and recovery systems	30.0
Catapult and rocket	62.0
Headrest installations (2)	8.0
Stabilization booms (2)	100.0
Recovery parachutes (2)	60.0
Recovery system (less parachutes)	18.0
Water and ground landing systems	37.0
Survival gearboxes and structural attachments	13.0
Proposed specification weight	793.0
Console A/C equipment and control sticks	136.0
Survival gear	85.0
Capsule weight (empty)	1014.0
Ejection rails	50.0
Capsule installed weight (empty)	1054.0
50th percentile men (2) with personal gear	354.0
Total weight installed	1408.0

3. COCKPIT POD CAPSULES

a. STANLEY CANOPY CAPSULE

The Stanley canopy capsule is the result of an Air Force sponsored program which was initiated in 1952 to develop a general purpose escape capsule for protecting the pilot against the adverse conditions of windblast, excessive deceleration, and low ambient pressures and temperatures during emergency escape. The general-purpose concept was later changed to have the capsule design oriented to the Convair F-102 interceptor airplane. However, the principal features of the universal capsule were adhered to throughout the design work to guarantee adaptability to most modern fighters. A full-scale working mockup of the capsule was constructed to test and demonstrate the feasibility of the capsule and its various operating components. This program included a weight and balance estimate, qualitative capsule low-speed aerodynamic tests, preliminary study of parachute recovery, capsule structural design, wind tunnel tests, estimated capsule aerodynamic characteristics and trajectory studies, and full-scale sled ejection tests. Construction of sled test capsule models was initiated in 1957, and sled testing was started in June of 1959. Sled tests were terminated in 1960 after the loss of available capsule models.

The Stanley canopy capsule escape system is a separating canopy section which comprises the aircraft canopy as the main body of the capsule. This is accomplished by enclosing the lower surface to produce a pressure-tight compartment. The system design performance objectives were to provide safe escape at speeds of from 150 KEAS to 700 KEAS and to Mach 2.2 at 35,000 feet altitude. The general arrangement of the capsule with sled test instrumentation is shown in Fig. 137. Figure 138 shows the capsule with hatch closed, doors and seat retracted, and occupied.

Escape is initiated by pulling two handgrips at the forward end of the seat pan. The crewman is then automatically restrained, the seat is bottomed, and the crewman and seat are retracted up and aft into the canopy. The clam-shell doors at the bottom of the capsule are retracted to their closed position which seals the capsule. Retraction of the doors initiates the firing of four explosive bolts, releasing the capsule from the aircraft. The RATO solid-propellant rocket ejection unit then fires, ejecting the capsule from the aircraft. The nominal thrust rating of the RATO unit is approximately 9200 pounds for 0.25 second. During capsule ejection, the control stick, personal leads, and instrument leads are disconnected. As the capsule clears the aircraft, a static line attached to the aircraft structure fires the drogue gun which deploys the 3.44-foot diameter guide surface-type drogue parachute. When the capsule has slowed down to 190 knots or less and is below 10,000 feet altitude, an automatic release device releases a lanyard which permits the drogue parachute to deploy the 48-foot diameter formed gore type main recovery parachute. A manual release is provided for the pilot when it is necessary to override the automatic main parachute release system.

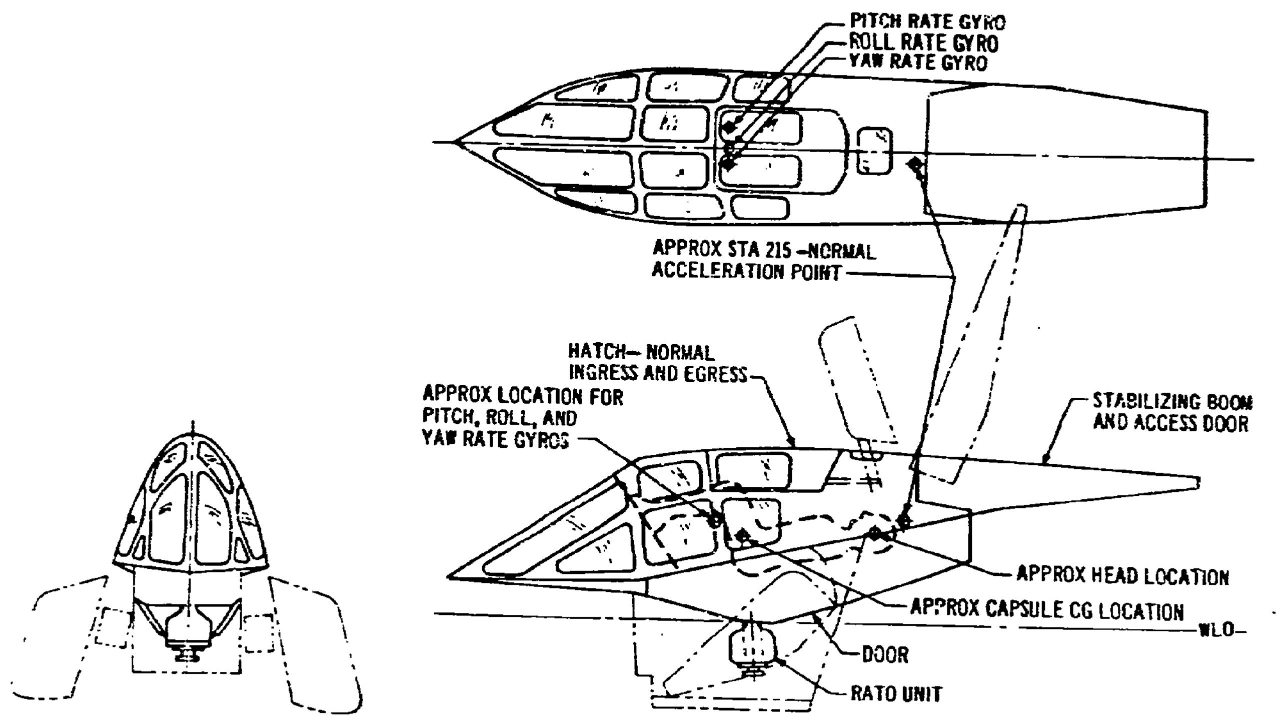


Figure 137. Stanley Canopy Capsule – General Arrangement

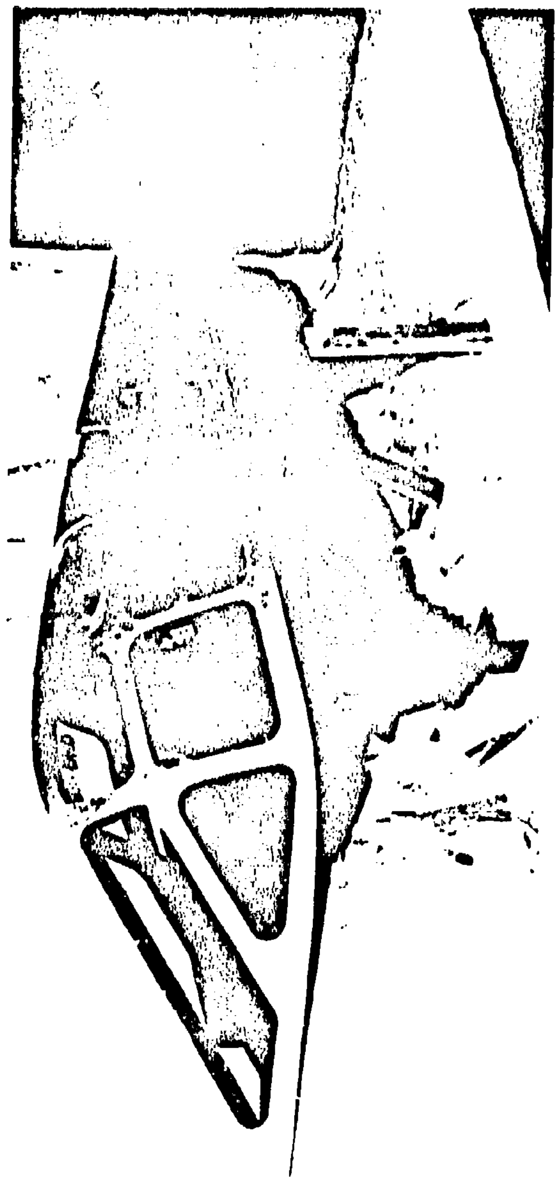


Figure 138. Stanley Canopy Capsule – Three-Quarter Front View

Wind tunnel tests of the Stanley canopy capsule were conducted under an Air Force contract. The supersonic tests were conducted in the wind tunnel at the M.I.T. Naval Supersonic Laboratory. The transonic tests were run in the 10-foot tunnel at the Wright Air Development Center. The general aerodynamic characteristics of the capsule model were determined in the range from Mach 0.6 to 3.0. Stable-trim attitudes in the pitch plane were located, and tests were carried out to obtain yaw-stability data at these positions.

Six track tests of the canopy escape capsule were conducted at speeds of 150, 300, and 400 KEAS at the Hurricane Supersonic Research Site, Utah, by the Coleman Engineering Company, Inc., under an Air Force contract. The purposes of these tests were to evaluate the ejection and recovery of the capsule and to obtain aerodynamic, structural, component functioning, and physiological information. The tests showed that unguided separation of the capsule was successful, that proper functioning of the recovery system was demonstrated, and that low-level ejection capability of the escape capsule was indicated.

The effect of capsule pitchup on the normal acceleration during the 300 KEAS sled test, as reported in Ref. 6, is shown in Fig. 139. This figure gives transverse acceleration (head), normal acceleration (station 215), and normal acceleration (CG). All three traces show the initial acceleration due to thrust of the rocket, and a second acceleration of lesser magnitude that corresponds to the time of maximum pitchup as can be seen by comparison with Fig. 140.

Pitch, roll, and yaw characteristics recorded during the 300 KEAS sled test are shown in Fig. 140 and illustrate the instability of the capsule shortly after ejection. The capsule was unstable even after full development of the drogue parachute, indicating the importance of achieving flight stability early in the escape sequence.

Figure 141 gives a summary of the indicated tail clearance for straight and level flight as derived from sled test trajectory data at various speeds. This figure indicates sufficient clearance for speeds between 150 and 300 KEAS.

Table XXIX gives the system weight breakdown.

Table XXIX. Stanley Canopy Capsule Escape System Weight Breakdown

Item		Weight (Lb)
Capsule structure		472.0
Main canopy structure	137.6	
Glass	238.4	
Hatch (including glass)	32.1	
Bottom door (including latches)	31.4	
Stabilizing boom	32.5	
Seat system		87.2
Seat assembly (including leg recovery and controls)	25.4	
Lap belt, harness and inertia reel installation	6.7	
Retraction carriage assembly (including headrest and actuator pin pull)	29.9	
Seat retraction cylinder	14.5	
Seat bottoming cylinder	4.5	
Seat adjust actuator	6.4	
Recovery system		68.2
Main parachute installation (includes manual release)	51.4	
Drogue parachute and installation	6.3	
Drogue gun	5.1	
Main parachute release device	5.4	
Equipment		170.4
Pilot's instrument panel and instruments	47.4	
Radar scope	50.0	
Instrument and radar disconnects	11.0	
Control stick and disconnects	13.8	
Personal lead and disconnect	1.8	
RATC ejection unit installation (charge expanded)	34.1	
Survival kit	12.3	
Crew		230.0
Installation and expendable items		35.9
Capsule main disconnect system	15.0	
RATO unit propellant	13.8	
Seal-airplane to capsule	7.1	
Total Weight		1063.7

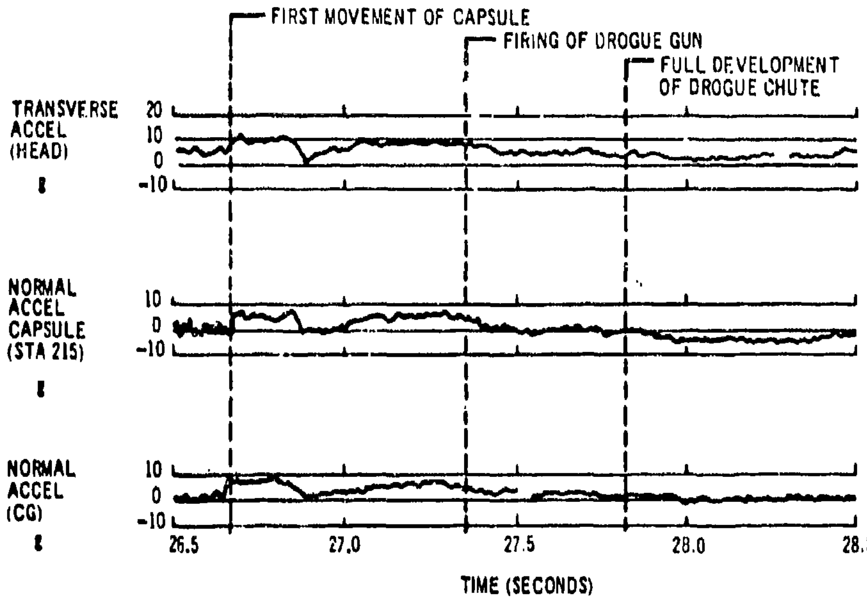


Figure 139. Stanley Canopy Capsule – Oscillograph Trace of Normal Acceleration – 300 KEAS Sled Test

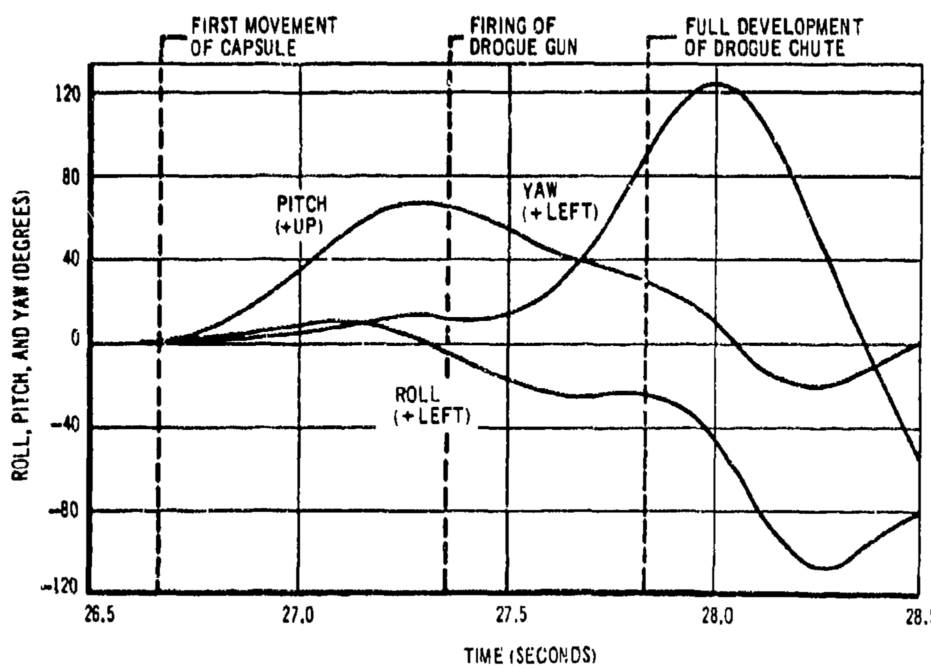


Figure 140. Stanley Canopy Capsule – Attitude of Capsule versus Time – 300 KEAS Sled Test

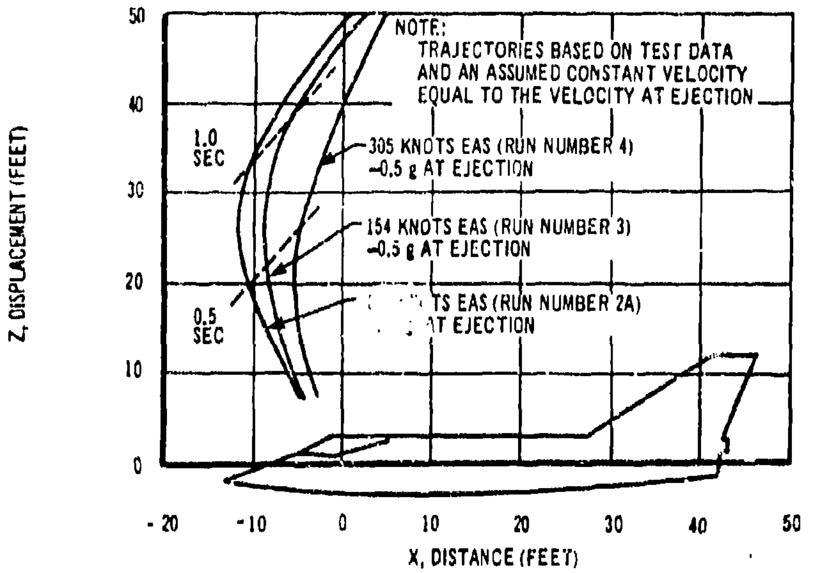


Figure 141. Stanley Canopy Capsule – Tail Clearance Indicated by Test Trajectories for Straight and Level Flight

b. GENERAL DYNAMICS F-111 CREW MODULE ESCAPE SYSTEM

The F-111 ejectable crew module escape system was developed by General Dynamics Corporation and McDonnell Aircraft Corporation. The crew module forms an integrated portion of the forward fuselage during normal flight, encompassing the pressurized cabin and forward portion of the wing glove. The system is designed for maximum protection for both crew members throughout the airplane performance envelope, including zero-altitude and zero-speed ejection capability. It also provides underwater escape capabilities and protects the occupants from environmental hazards on either land or water. Freedom of movement and comfort are enhanced by eliminating a man-fitted parachute and survival equipment. The crew module retains both crew members in the same side-by-side position occupied during normal flight. Adequate restraints protect the occupants in event of a crash landing. The crew module features a five-point hookup — two lap belt buckles, an upper torso harness buckle, an oxygen hose, and an interphone lead. The crew module is engineered around the "shirt sleeve" flying concept and contains an emergency oxygen supply and emergency cabin pressurization supply. Full pressure suit capability also is incorporated for use if desired. Both Air Force and Navy airplanes have identical escape systems. A photograph of the capsule is shown in Fig. 142 and the module geometry is shown on Fig. 143. Figure 144 shows the location of escape system components. The ejected weight of the crew module is approximately 3,000 pounds, comprising approximately 1/3 structure and 2/3 equipment and flight personnel.

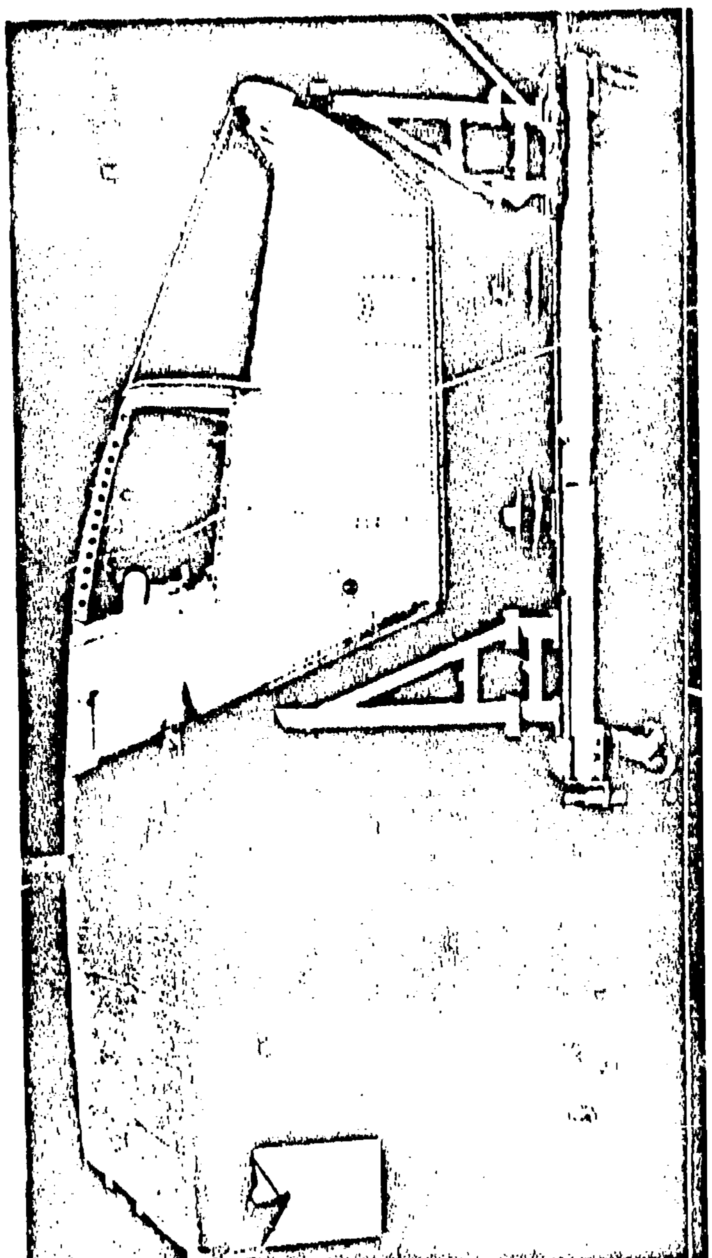
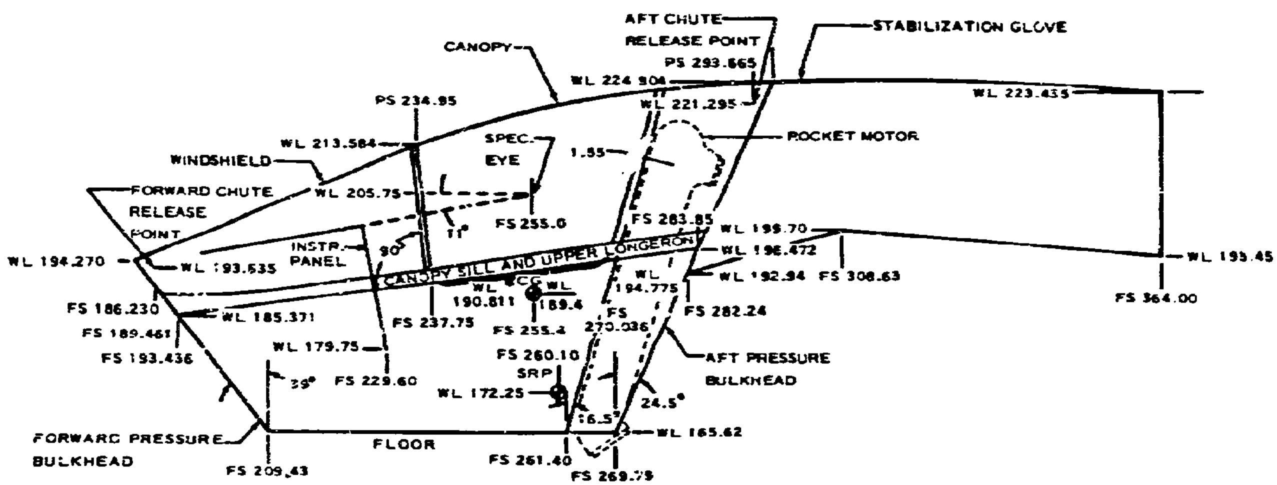


Figure 142. F-111 Crew Module



*CG
EJECTED WEIGHT
STAB-BRAKE CHUTE DEPLOYED
TWO 95 PERCENTILE CREWMEMBERS

Figure 143. F-111 Crew Module Geometry

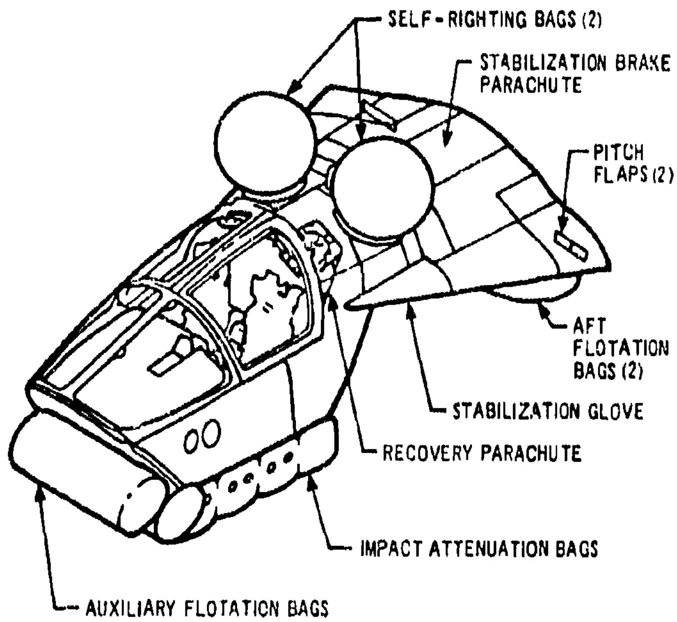
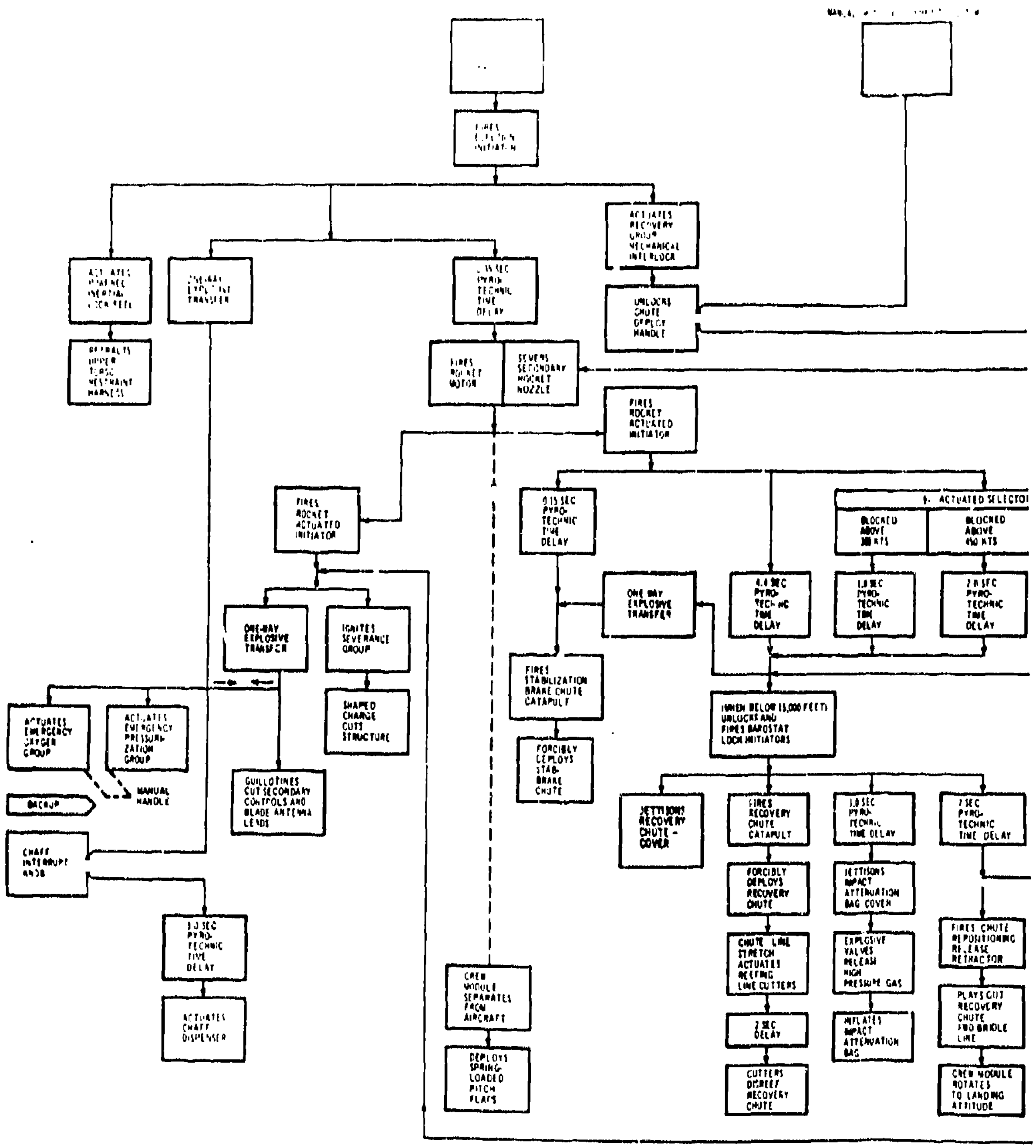


Figure 144. F-111 Crew Module Escape Equipment Arrangement

Figure 145 is a schematic diagram of the system, and Fig. 146 shows the escape sequence. Either crew member may initiate ejection by pulling either of two handles located between the seats on the center console. After actuation, all succeeding functions including the landing are automatic. Each handle can fire an initiator that, in turn, retracts both powered inertia-lock reels, actuates the emergency oxygen and cabin pressurization groups, actuates the chaff dispenser, fires explosive guillotines (severing secondary controls and antenna leads), unlocks the manual recovery chute deployment handle (provided as a backup to the automatic deployment system), and fires a 0.35-second time delay which in turn ignites the rocket motor. Rocket pressure buildup fires two initiators.

The first initiator detonates an explosive train which actuates the emergency oxygen and pressurization groups, if not already actuated by the ejection handle initiator or the manual backup handle; actuates the chaff dispenser, if not already actuated; and ignites the crew module severance group.

The severance group shaped-charge train cuts the structure to release the crew module from the airplane. Other systems separate through disconnects and the crew module is free to be thrust from the fuselage by the solid propellant rocket motor. The rocket motor is a two-mode binozzle unit. Figure 147 shows the rocket motor thrust-time characteristics for the low- and high-speed modes.


ACTUATES RECOVERY GROUP MECHANICAL INTERLOCK
UNLOCKS CHUTE DEPLOY HANDLE
ACTUATES HARNESS INERTIAL LOCK REEL
RETRACTS UPPER TORSO RESTRAINT HARNESS
FIRES ROCKET MOTOR
SEVERS SECONDARY ROCKET NOZZLE
FIRES ROCKET ACTUATED INITIATOR
0.15 SEC PYRO-TECHNIC TIME DELAY
ONE WAY EXPLOSIVE TRANSFER
4.4 SEC PYRO-TECHNIC TIME DELAY
ACTUATED SELECTOR
BLOCKED ABOVE 300 KTS
BLOCKED ABOVE 450 KTS
1.8 SEC PYRO-TECHNIC TIME DELAY
2.8 SEC PYRO-TECHNIC TIME DELAY
FIRES ROCKET ACTUATED INITIATOR
ONE-WAY EXPLOSIVE TRANSFER
IGNITES SEVERANCE GROUP
SHAPED CHARGE CUTS STRUCTURE
FIRES STABILIZATION BRAKE CHUTE CATAPULT
FORCIBLY DEPLOYS STAB. BRAKE CHUTE
(WHEN BELOW 15,000 FEET) UNLOCKS AND FIRES BAROSTAT LOCK INITIATORS
ACTUATES EMERGENCY OXYGEN GROUP
ACTUATES EMERGENCY PRESSURIZATION GROUP
MANUAL HANDLE
BACKUP
GUILLOTINES CUT SECONDARY CONTROLS AND BLADE ANTENNA LEADS
CHAFF INTERRUPT KNOB
PYRO-TECHNIC TIME DELAY
ACTUATES CHAFF DISPENSER
JETTISONS RECOVERY CHUTE COVER
FIRES RECOVERY CHUTE CATAPULT
3.8 SEC PYRO-TECHNIC TIME DELAY
7 SEC PYRO-TECHNIC TIME DELAY
FORCIBLY DEPLOYS RECOVERY CHUTE
JETTISONS IMPACT ATTENUATION BAG COVER
FIRES CHUTE REPOSITIONING RELEASE RETRACTOR
CHUTE LINE STRETCH ACTUATES REEFING LINE CUTTERS
EXPLOSIVE VALVES RELEASE HIGH PRESSURE GAS
PLAYS OUT RECOVERY CHUTE FWD BRIDLE LINE
2 SEC DELAY
INFLATES IMPACT ATTENUATION BAG
CUTTERS DISREEF RECOVERY CHUTE
CREW MODULE ROTATES TO LANDING ATTITUDE
CREW MODULE SEPARATES FROM AIRCRAFT
DEPLOYS SPRING-LOADED PITCH FLAPS

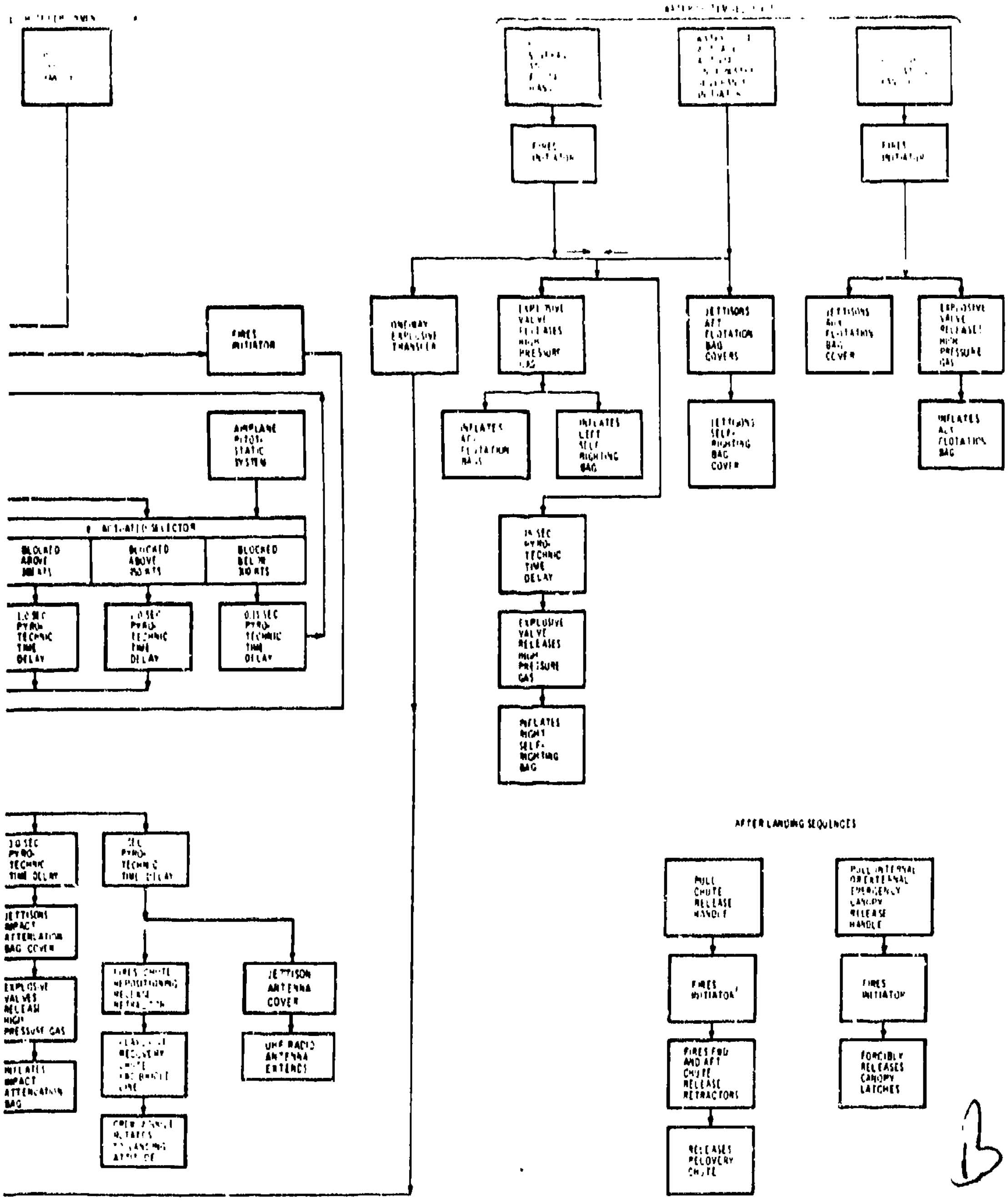


Figure 145. F-111 Crew Module Escape System Diagram

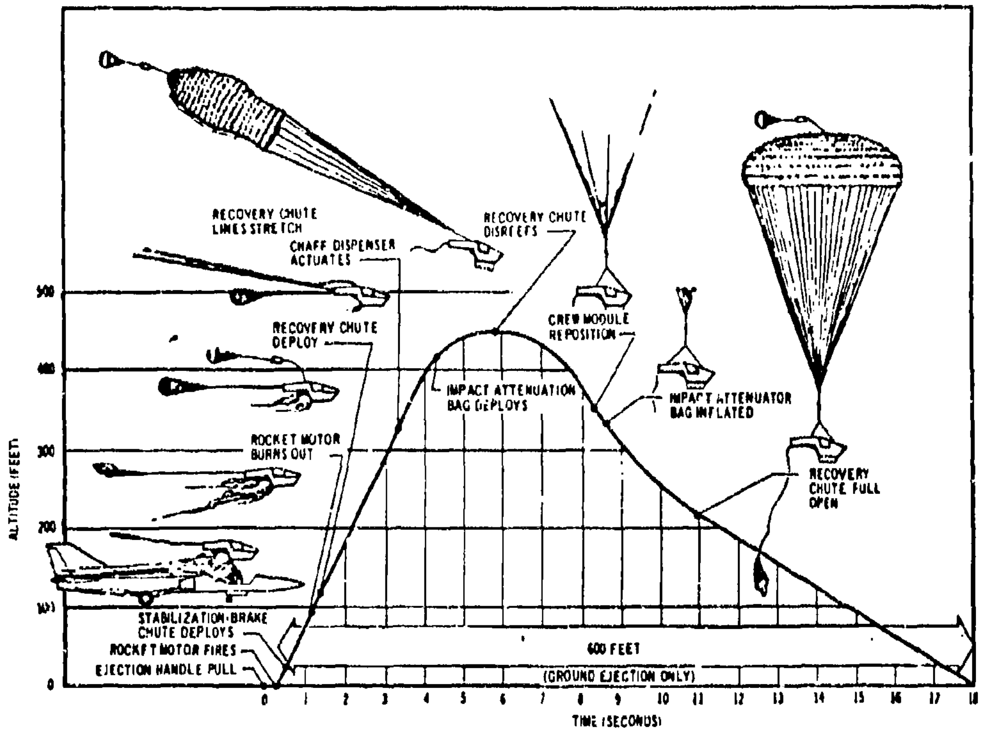


Figure 146. F-111 Crew Module Escape Sequence

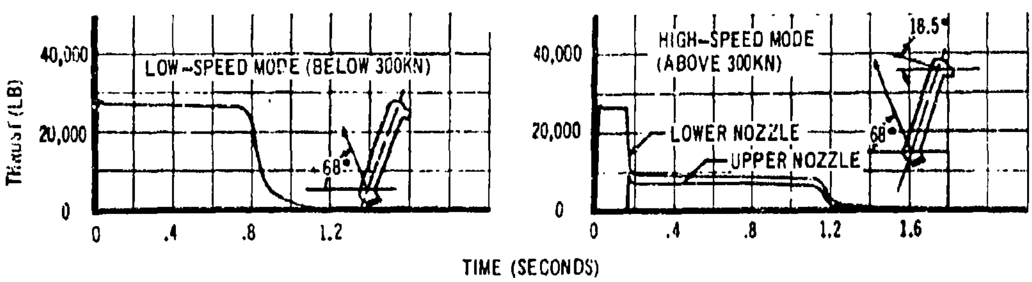


Figure 147. F-111 Crew Module Two-Mode Binozzle Rocket Motor Thrust Characteristics

Crew module stabilization is critical upon separation and while close to the parent aircraft. The stabilization glove provides stability and aerodynamic lift. The stabilization-brake parachute provides additional stability and deceleration. Immediately upon separation of the crew module, two spring-loaded pitch flaps deploy on the underside of the glove to provide longitudinal stability. At speeds above 300 knots, the upper secondary rocket nozzle is severed. This results in lowering the thrust at the lower main nozzle and supplying a thrust at the upper nozzle which acts on a line above the module center of gravity. The counter moment provided by the upper nozzle prevents excessive pitch-up at high speeds.

The second rocket-actuated initiator ignites a shielded mild detonating cord (SMDC) train that fires the stabilization-brake parachute catapult. The six-foot diameter Hemisflo-type stabilization parachute is ejected aft from a compartment on top of the wing glove. It is timed to deploy 0.15 second after rocket motor ignition, so as to be fully effective at time of separation.

The rocket actuated initiator also provides power, through SMDC, to the q-actuated selector. The q-actuated selector continuously senses aircraft speed and selects either the low- or high-speed rocket mode, and the proper time delay for recovery parachute deployment. For speeds above 300 knots the selector, through a SMDC train and a 0.15 second time delay, fires the rocket motor secondary nozzle flexible linear shaped charge (FLSC) severance ring, thereby activating the secondary nozzle. The recovery parachute deployment time delays as selected by the q-actuated selector are: 1.0 second for speeds below 300 knots, 2.0 seconds for speeds between 300 and 450 knots, and 4.4 seconds for speeds above 450 knots. These time delays assure crew module deceleration to a safe parachute deployment speed before propagating the detonation to the barostat delay device.

The barostat delay prevents parachute deployment above 15,000 feet. The aneroid bellows of this device are normally locked to prevent constant cycling and wear. The firing of SMDC into the barostat inlet ports initiates an explosive charge that retracts the pins that normally lock the bellows. Below 15,000 feet, atmospheric pressure compresses the bellows sufficiently to release the firing pins that initiate booster caps and continue the detonation sequence that removes the recovery chute cover, and fires the recovery parachute catapult.

The catapult forceably deploys the 70-foot flat diameter ringsail parachute at a velocity sufficient to ensure proper bag strip-off. The opening shock is minimized by reefing the parachute to approximately twelve percent of its full diameter. Line stretch fires the reefing line cutters to disreef the parachute after two-seconds delay. The canopy then expands to full-blossom. Approximately 7 seconds after parachute catapult firing, an explosively operated pin retractor releases the repositioning bridle cable allowing the crew module to assume the correct touchdown attitude. Pulling the parachute release handle actuates explosive releases at both recovery parachute attach points. The parachute should be jettisoned to avoid dragging the crew module in high winds and, if on water, to prevent wave action on the parachute that would tend to overturn or prevent self-righting of the crew module.

Impact attenuation bags are provided to reduce the landing shock of the crew module during either land or water impact. The impact system is activated by the barostat lock initiator through a 3.0-second delay. The time delay prevents bag inflation before parachute deployment to ensure against loss of the bag. After the required delay, the detonation sequence continues through the SMDC to sever the attenuation bag severable cover and fire the explosive valves in the pressure sources (nitrogen bottles). The impact bags are inflated and maintained at a pressure of 2 ± 1/4 psig. Landing impact is absorbed by controlled gas expulsion from the impact attenuation bag blowout plugs.

After a water landing following crew module ejection or in the event the aircraft is ditched with the module still attached, the severance and the primary flotation system may be activated by pulling the severance and flotation handle. In the event the crew is incapacitated and the aircraft should submerge to a depth of ten to twenty feet, the automatic underwater severance initiator will activate the system. Following either manual or automatic activation, SMDC will transfer detonation throughout the system to actuate the severance and emergency oxygen systems (if not already accomplished) inflate the self-righting bags (located on the stabilization glove upper surface) and inflate the aft flotation bags (located on the glove underside). Inflation of the self-righting bags is sequenced so that the left bag is inflated first. The right bag is inflated after a delay of 75 seconds.

Should the crew module flood, flotation is aided by auxiliary bags located on the forward crew module separation plane surface. Bag inflation is achieved by pulling the auxiliary flotation handle.

A bilge pump located on the crew module floor can be connected to the lower portion of the first station crew member's control stick. The control stick is used as the bilge pump handle to expel water that might have leaked in or inflate the flotation bags; a simultaneous operation.

Egress from the crew module is accomplished by releasing the canopy latches, using either the normal or emergency canopy release handles, and rotating the canopy hatch up on either or both sides. A radio beacon set, two UHF radio sets, and a flashing light beacon are provided to facilitate rescue. The crew module's use as a shelter after a ground or water landing is augmented by a full complement of rations, clothing, and other survival equipment.

The flexible linear-shaped charge (FLSC) is used extensively in the F-111 crew module escape concept. Its function is to ensure the complete severance of crew module-to-airplane splice plates. Subsequent to ejection, the severance of various covers in the external skin is also required.

FLSC is an explosive formed in an inverted "V" cross section and sheathed in a thin metal cover. It is made up in exact lengths for use in severance strips, covers, and FLSC holders. A booster tip is installed on each end. The amount of explosive per foot of FLSC has been selected to cut specified thicknesses of metal. Success in cutting the metal depends on the

proper charge and the proper gap or "stand off" between the charge and the surface to be cut. This "stand off" is established by the design of the holder, cover, or strip installations. Deviations of ±0.010 inch will not seriously degrade cutting.

Certain access covers are severed to free the parachutes and the various bags. These covers are installed over FLSC holders and contain bonded silicone rubber strips that seal the opening. Severable covers are installed over the right self-righting bag, the impact attenuation bags, both parachutes, and the rocket-motor compartment. These covers have a machined groove under the area to be cut. They are secured by screws or bolts around their peripheries. Cutting occurs just inboard of the line of fasteners. FLSC's are bonded into the grooves. The ends of these charges contain booster assemblies to ensure initiation of the FLSC by the matching booster assembly installed under the cover. The installed FLSC is protected by a covering of metal foil bonded to the cover over the FLSC. This covering is a moisture barrier and ensures that the FLSC remains in good condition.

FLSC severance strips are installed under cover plates that lie over the splice plates that join the crew module to the aircraft. The cover plates are extruded aluminum and contain a groove into which the FLSC severance strip is pressed when the plates are installed. The FLSC severance strips used in this application are of light gauge sheet metal with a "V" formed into them. The FLSC is bonded into the "V" and protected by a seal. These severance strips are very long and formed to the contour of the module at the fuselage splice planes. Antenna leads, secondary control cables, and an oxygen line are severed by explosive guillotine cutters. Disconnects located in the crew module floor are used to separate the cabin air duct, defog air duct, electrical package cooling duct, pressure suit air duct, cabin pressure regulator lines, flight controls, and electrical wiring.

The crew module seats and restraint harness will accommodate 5 through 95 percentile personnel. The seats are light weight and constructed of aluminum and honeycomb. The cushions are made of a plastic foam, giving maximum support and comfort for extended flights. Cushions are of a low rebound-type material that prevents injury to the crew by amplifying accelerations during the escape sequence. An electric actuator controls the up-and-down movement of the seat. The fore-and-aft motion is accomplished by releasing a mechanical lock and a crew member moving the seat pan in the carriage. Each seat has five inches of powered vertical adjustment and five inches of manual fore-and-aft adjustment. The headrest is spring-loaded and, when mechanically released by a crew member, can be set to any desired position and relocked. The upper torso harness is the basic cruciform design with additional lateral restraint (horizontal chest straps). The powered inertia-lock reel is mounted in the headrest housing and is attached to the upper torso restraint harness. It is explosively activated during ejection and, through the harness take-up, places the crew member in the most desirable position for ejection. Figure 148 shows the general arrangement of the crew seat and restraint system.

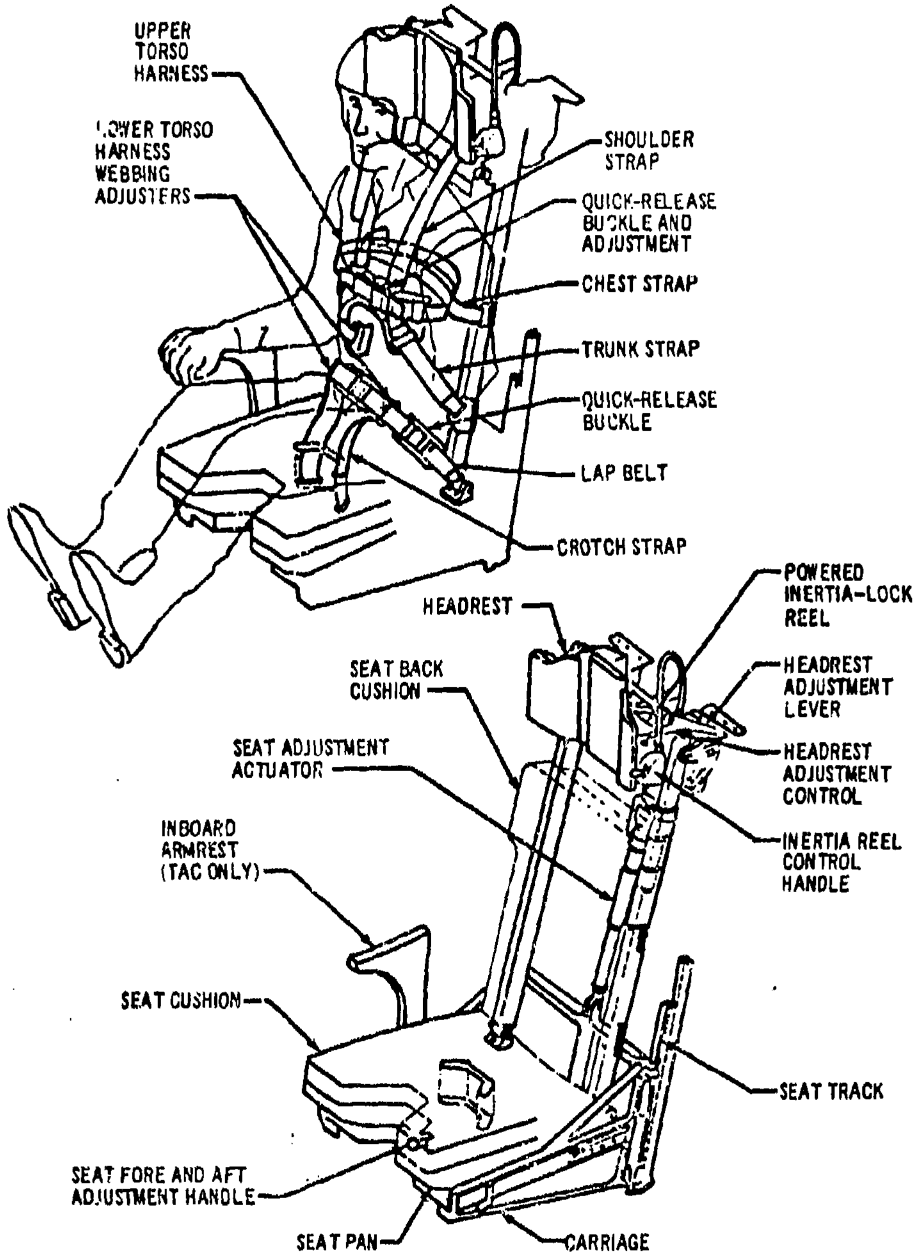


Figure 148. F-111 Crew Module Crew Seats and Personnel Restraint

The F-111 crew module has been subjected to extensive development and qualification tests. These include six full-scale sled ejections with boiler plate hardware, and 10 full-scale ejections with production hardware. Speeds for each test, in the order run, are as follows: (1) 100 KEAS, (2) Static, (3) Static, (4) 300 KEAS, (5) 380 KEAS, (6) 300 KEAS, (7) 450 KEAS, (8) 450 KEAS, (9) 450 KEAS, (10) 600 KEAS, (11) 100 KEAS, (12) Static, (13) 250 KEAS, (14) Static, (15) 450 KEAS, and (16) 800 KEAS.

The lowest apogee was approximately 250 feet. The highest apogee was approximately 1,700 feet. The range down the track varied from approximately 400 feet to approximately 3,700 feet. The last test (800 KEAS) had an apogee of 1,775 feet, recovery height of 1,400 feet, range of 3,336 feet, and a flight time of 68.1 seconds. Figure 149 is a photograph of the crew module immediately following rocket ignition and severance from the parent aircraft during a sled test.

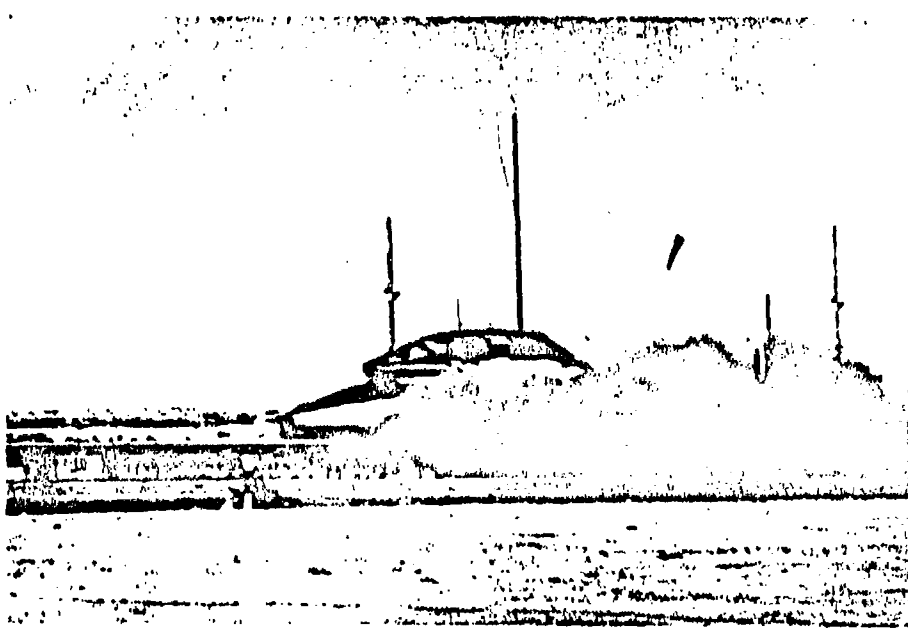


Figure 149. F-111 Crew Module Sled Ejection Test

4. SEPARABLE NOSE CAPSULES

a. LTV VOUGHT AERONAUTICS INTEGRATED FLIGHT CAPSULE

The escape system is the result of an experimental design based on the LTV Vought Aeronautics F-8A Crusader aircraft. The escape system consists of a separable nose section which comprises the forward fuselage section. The capsule project was a research and development program conducted under a Naval Air Systems Command contract for the purpose of designing the system and proving the operational feasibility of its concept. The system is designed to provide safe escape for a single crewman at the landing configuration stalling speed of the airplane for a zero-altitude, zero sink speed condition and at all altitudes within the performance capabilities of the F-8A airplane. The escape system performance envelope shown in Fig. 150 is compatible with the capsule design criteria and the flight envelope of the F-8A. The general arrangement of the integrated flight capsule is shown in Fig. 151. The mockup of the capsule as modified to incorporate the "wrap around" concept is shown in Fig. 152.

In the event of an inflight emergency, actuation of either the manual switch or the "dead man's" switch initiates the sequence of events necessary for escape and recovery. Escape on the runway at the stalling speed of the airplane is designed for manual initiation only. The semiautomatic "dead man's" mode of escape is designed for the recovery of an incapacitated pilot. First, the fuel supply to the engine afterburner is shut off, pilot restraint is energized, and four external stabilizer fins are actuated to stabilize the capsule after separation. After a time delay of one second, the capsule is separated from the afterbody by a linear-shaped charge (Fig. 153). Simultaneous with this event, two

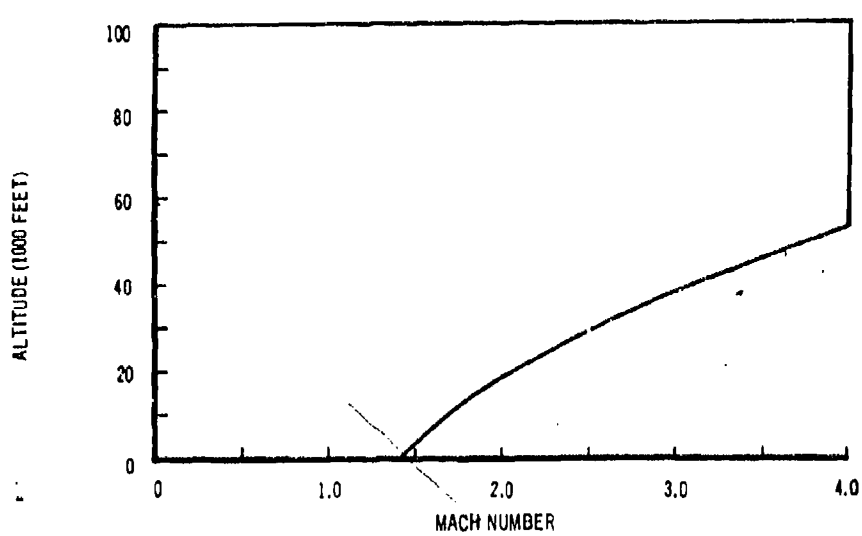


Figure 150. LTV Vought Aeronautics Capsule Escape System Performance

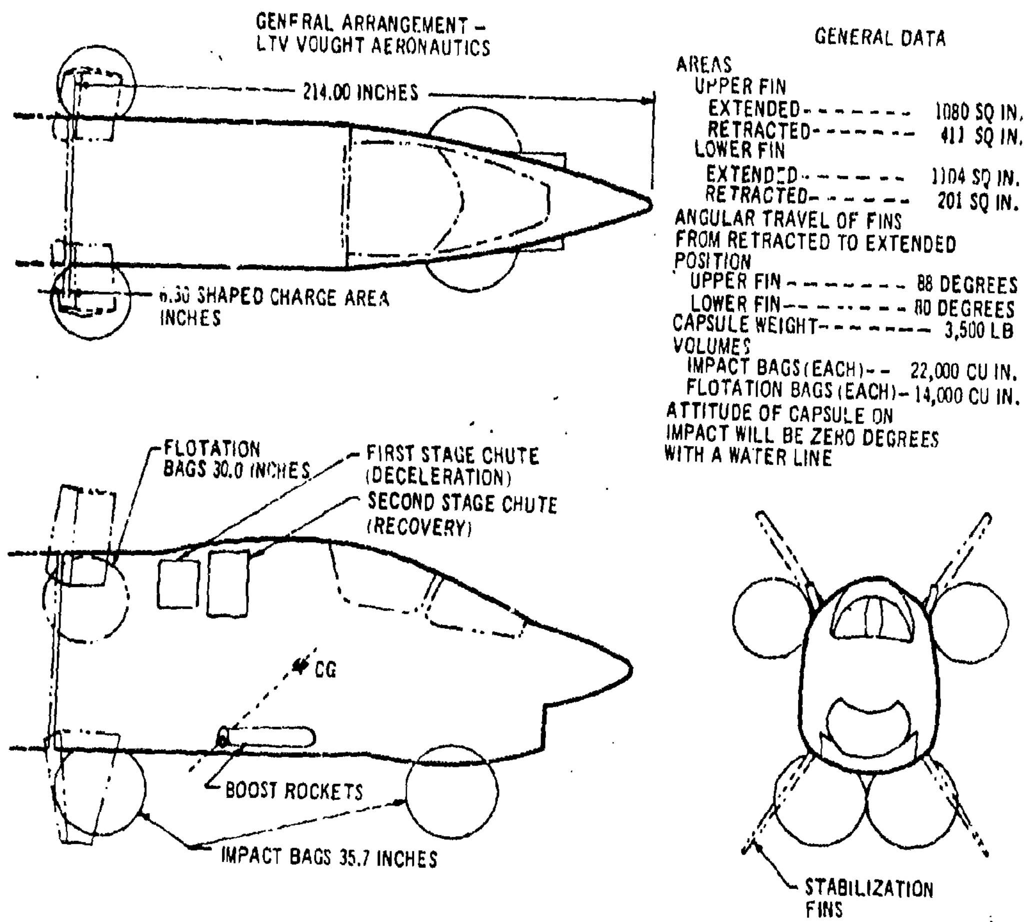


Figure 151. LTV Vought Aeronautics Capsule – General Arrangement

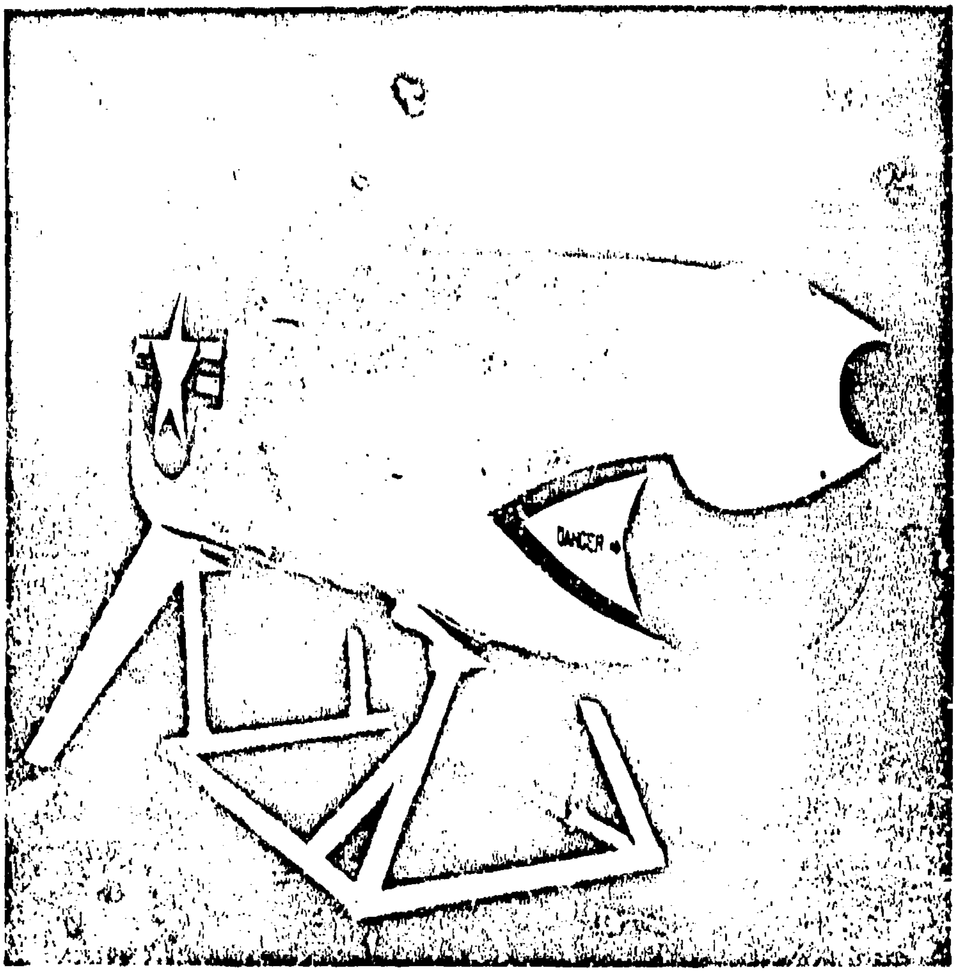


Figure 152. LTV Vought Aeronautics Integrated Flight Capsule Mockup

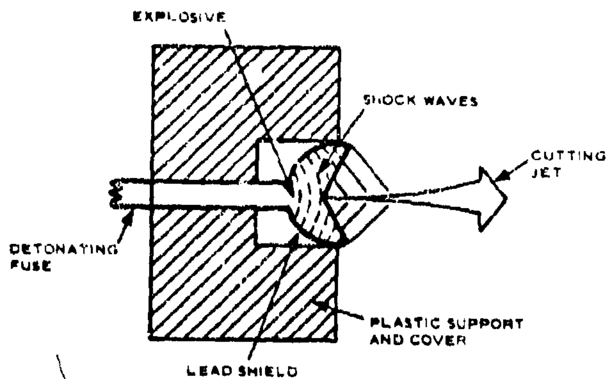


Figure 153. LTV Vought Aeronautics Integrated Flight Capsule Shaped Charge Operation

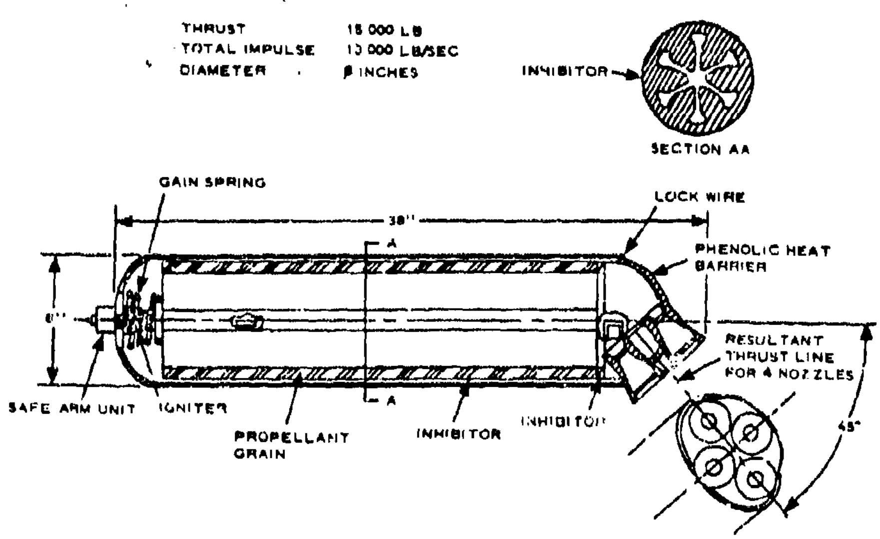


Figure 154. LTV Vought Aeronautics Integrated Flight Capsule Boost Rocket System

boost rockets are initiated to provide clearance with the afterbody at separation and sufficient altitude during low-level escape. The boost rocket system is shown in Fig. 154. The sequencing functions of the deceleration and recovery system are shown in Fig. 155. The parachute recovery system's first stage (deceleration parachute) consists of a single nine-foot diameter ribbon parachute. The second stage (recovery parachutes) is a cluster of three 40.5-foot diameter flat circular parachutes. Shortly after capsule separation from the aircraft, the rescue detection and emergency communications are actuated as shown in Fig. 156.

Four 35.7-inch inflatable bags absorb the impact energy of a capsule landing. These bags are automatically inflated by high-pressure air when the second-stage parachute is opened.

If the airplane should go into the water with the capsule attached, a water-actuated switch deactivates the firing circuits to the boost rockets, impact bags, and the parachutes and initiates the separation sequence. The capsule is separated by a shaped charge, the two 30-inch bags are inflated from an air bottle, and the capsule rises to the surface. At the surface, the emergency communications and other rescue devices become operative.

The results of computer analysis of escape from pilot-induced oscillation and divergent roll maneuvers show that the capsule remains stable and that the limits on pilot tolerance to accelerations are not exceeded throughout the escape trajectories. The angle-of-attack and angle-of-sideslip curves for Mach 1.2 (sea level condition) are shown in Fig. 157.

One of the most critical escape conditions occurring within the airplane flight envelope is the low-altitude, high-speed condition. Figure 158 illustrates this condition based on the maximum sea level speed of the F-8A flight test vehicle.

b. LOCKHEED F-104 CAPSULE

A track test program was conducted by the Aeronautical Systems Division, Flight Dynamics Laboratory to further investigate the feasibility of a nose capsule crew escape system. This program was initiated due to the favorable results obtained from the preliminary investigation and design study conducted by the Lockheed Aircraft Corporation on a separable nose capsule. The capsule studied was the nose section of the single place F-104 aircraft with an increased hypothetical performance of 900 KEAS or Mach 4, whichever is lower, through an altitude range from sea level to 100,000 feet. Lockheed was requested to design and fabricate five capsules and a sled, based on the data evolved from the study program.

The five capsules fabricated were based upon the external contours of the single place F-104 aircraft. The cockpit bulkheads, windshield and canopy frames, seat pan, and headrest were in fact taken from the F-104 assembly line. The windshield glass was replaced by aluminum and the plexiglass in the canopy was replaced by fiberglass since strength rather than transparency was required. From the rear cockpit bulkhead aft, the capsule was primarily of steel construction in order to absorb the loads imposed in this area by the

stabilization wedges, rocket motor, and recovery system. The radome was replaced by a crushable aluminum nose cone designed so that it would buckle between rings and act as a shock absorber.

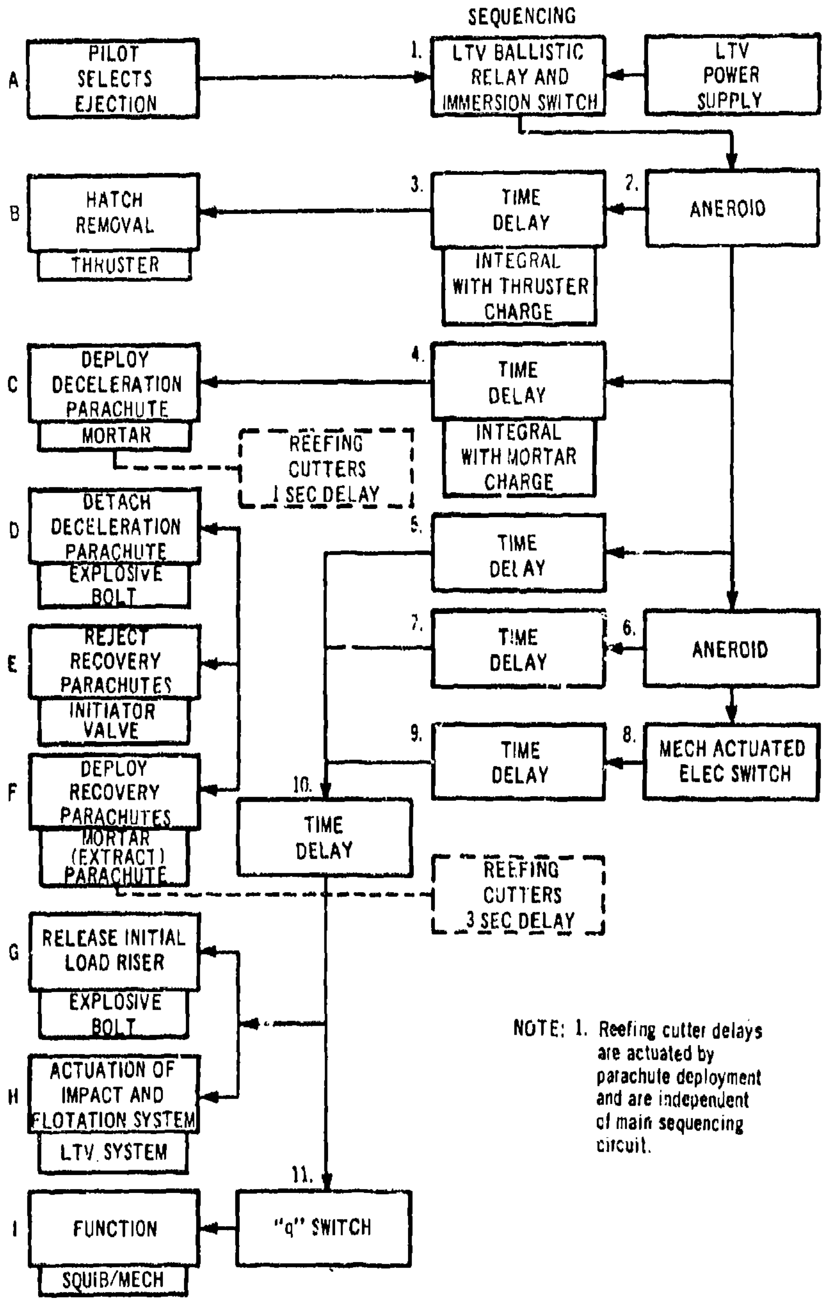
The major subsystems incorporated in the nose capsule escape system are the stabilization system, separation system, rocket motor, and the recovery system.

The stabilization system consists of three wedge-shaped booms, approximately seven and one half feet in length, extending from the back of the capsule 120 degrees apart around the periphery and 30 degrees out into the airstream. The wedges are triangular in cross section and 12 inches wide on each surface. In order to provide pitch stability in the high speed range, a 1.5 square foot trimmer plate was installed on the aft end of the upper wedge. Normally, each wedge would be contained in a recess in the fuselage and covered by a door which would be jettisoned during the first motion of the stabilization system deployment. In order to save development time, and since the wedges must be in the deployed position before capsule separation occurs, they were fixed in the deployed position throughout the test program.

The separation system designed for use on the ejectable nose capsule is a gas operated system. Gas from a generator in the aircraft interior will be piped to the cylinder-piston assemblies at the four attachment fittings, freeing them for separation by the action of the rocket motor. However, for the test program the device used for capsule retention and subsequent separation from the fuselage was an explosive nut. The capsule was attached to the sled fuselage at four places with one inch diameter aircraft bolts secured by captive explosive nuts. Each of the four explosive nuts was actuated by two pyrotechnic squibs on parallel firing circuits. If one squib should fail to fire, the other would be capable of effecting separation.

The XM-15 rocket motor (Frankford Arsenal), that was designed and built for this test program, is a solid propellant motor containing 12 tubular grains of HEX-12 propellant 2.85 inches in diameter. The assembled motor is 12 inches in diameter, 32 inches long (excluding the nozzle), and weighs 218 pounds. The rocket motor casings are made of stainless steel in order to permit reuse, which accounts for the casing and nozzle weight of 133 pounds. It is attached to the aft side of the cockpit bulkhead, on the capsule centerline, by six bolts and two shear pins. The rocket motor is designed to deliver a peak thrust of 45,000 pounds and a burning time of 0.5 seconds. Firing of the rocket motor is accomplished by two XM-21 squibs connected in parallel, either of which is capable of actuating the rocket motor igniter. Temperature capabilities for ignition of the rocket were only proven between 70 and 90 degrees Fahrenheit.

The capsule recovery system consists of a 71.5-foot nominal diameter (51 foot inflated diameter) ring slot main parachute, a 5-foot diameter Fist ribbon all speed pilot chute, and an XM-1 ejector gun. The entire assembly weighs approximately 125 pounds. The main parachute is pressure packed in a cloth bag and installed in a fiberglass compartment in the aft section of the capsule. The compartment door has a cavity for the pilot chute. The pilot chute is packed in a wedge-shaped deployment bag and is attached to the main



NOTE: 1. Reefing cutter delays are actuated by parachute deployment and are independent of main sequencing circuit.

APPROX SETTINGS	OPERAT
15,000 ft	1. Activates ... circuit upo... of ejection ... case of dit...
15,000 ft	2. Prevents h... removal or ... of recovery ... above 15,0...
0.75 sec	3. Prevents h... separation ... secs prior ... deceleratio... deployment
1.25 sec	4. Prevents de... prcht deplo... the velocity ... 710 knots E... deployment
6.1 sec	5. Prevents de... of deceleral... and deployn... recovery pr... the velocity ... 300 KTS T...
5,000 ft (6)	6 & 7. Provide sho... for improve... envelope be...
4.5 sec (7) / 2.0 sec	8 & 9. Provide low ... low speed e... capability s... actuated in ... with wing ti... mechanism
8.0 sec	10. Prevents ca... reorientatio... bag and flot... actuation un... is approxim... Also blocks ... parachute di... circuit until ... are damped. ... bag inflatio... separate LT... the ditching
6 g	11. Actuates rec... disconnect a...

EJECTION ALTITUDE

OPERATION	ABOVE 15,000 FT	15,000-5,000 FT	BELOW 5,000 FT
1. Activates power supply circuit upon selection of ejection except in case of ditching	1. Operative	1. Operative	1. Operative except after ditching
2. Prevents hatch removal or deployment of recovery system above 15,000 ft	2. Activates hatch removal and recy system circuits at 15,000 ft	2. Switch closed	2. Switch closed
3. Prevents hatch separation until 0.5 secs prior to deceleration prcht deployment	3. Activated by (2) at 15,000 ft	3. Operative	3. Operative
4. Prevents deceleration prcht deployment until the velocity is below 710 knots EAS (at full deployment)	4. Activated by (2) at 15,000 ft	4. Operative	4. Operative
5. Prevents detachment of deceleration prcht and deployment of recovery prchts until the velocity is below 300 KTS TAS	5. Activated by (2) at 15,000 ft	5. Operative	5. Operative (but see No. 6)
6 & 7. Provide shorter time for improved recovery envelope below 5,000 ft	6. Switch open makes time delay No. 7, inoperative	6. Switch open makes time delay No. 7, inoperative	6. Switch closed, allows time delay No. 7 to precede time delay No. 5 (but see 8 & 9)
	7. Inoperative	7. Inoperative	7. Operative
8 & 9. Provide low altitude, low speed escape capability switch actuated in conjunction with wing tilt mechanism	8 & 9. Inoperative	8 & 9. Inoperative	8 & 9. Operative at low speed (below about 200 knots) precedes TD No. 7
10. Prevents capsule reorientation and impact bag and flotation actuation until velocity is approximately 40 ft/sec Also blocks recovery parachute disconnect circuit until prcht "q" are damped. Flotation bag inflation actuated by separate LTV circuit in the ditching case	10. Activated at initiation of recovery parachute deployment	10. Activated at initiation of recovery parachute deployment	10. Activated at initiation of recovery parachute deployment
11. Actuates recovery prcht disconnect at impact	11. Operative on impact after delay (10)	11. Operative on impact after delay (10)	11. Operative on impact after delay (10)

B

Figure 155. LTV Vought Aeronautics Capsule – Sequencing Functions

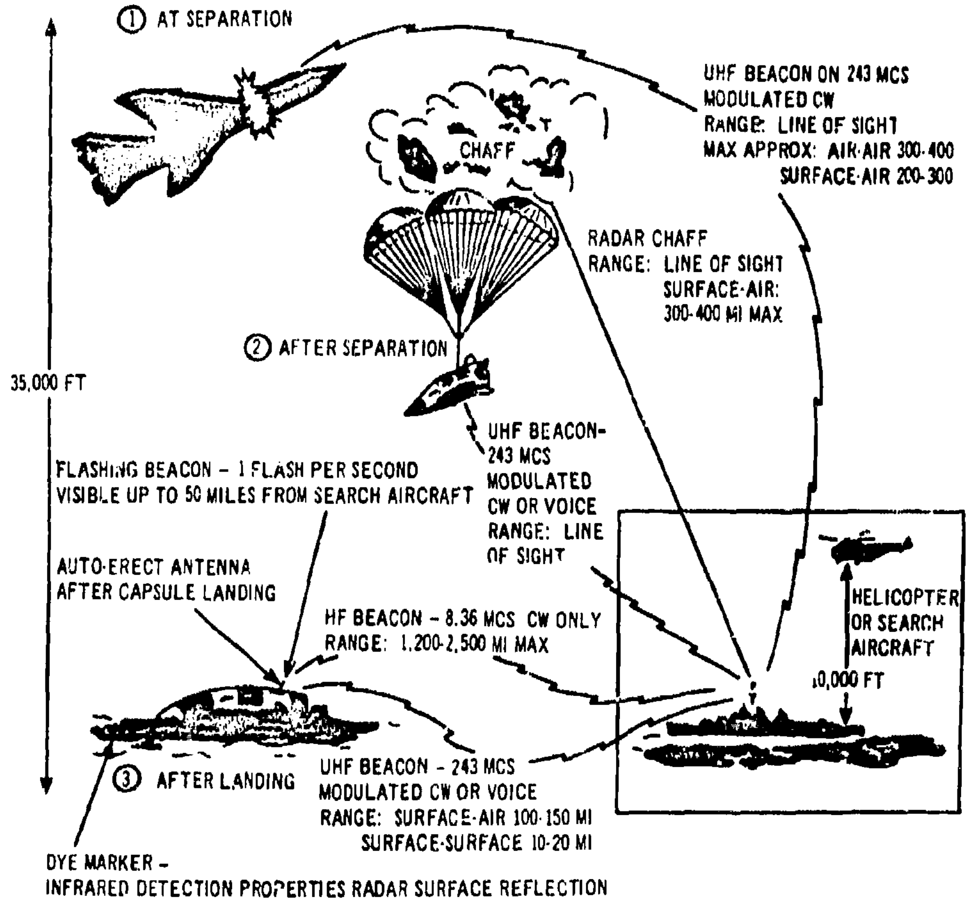


Figure 156, LTV Vought Aeronautics Integrated Flight Capsule Rescue Detection and Emergency Communications

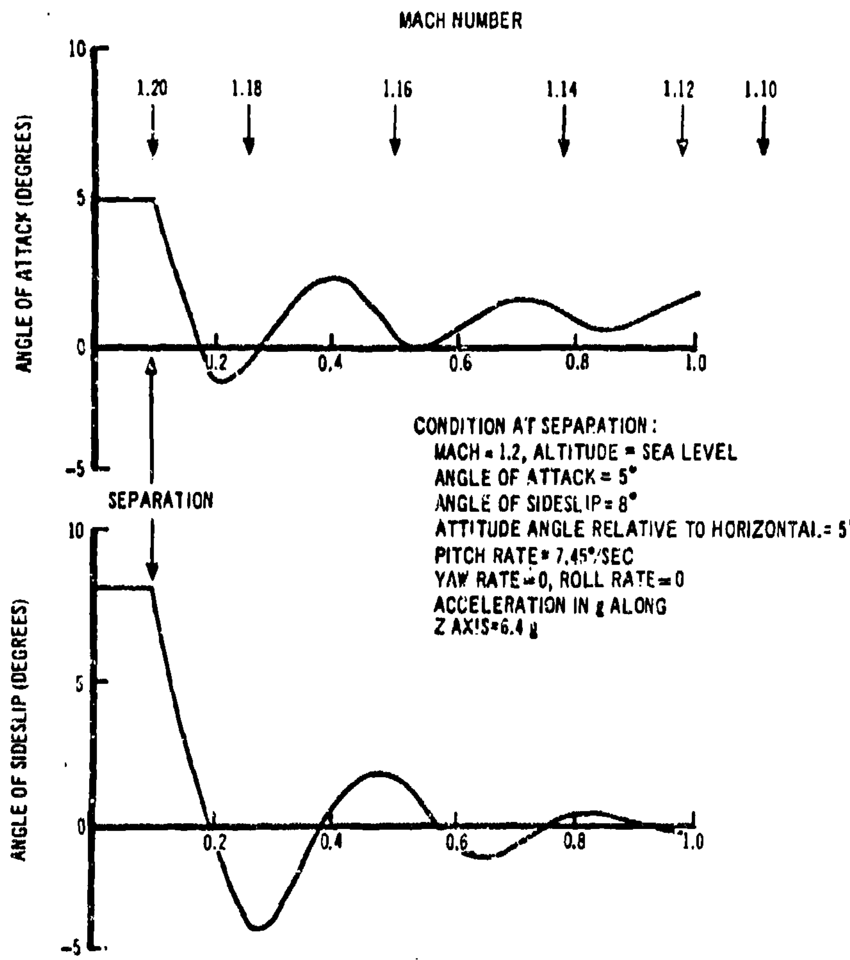


Figure 157. LTV Vought Aeronautics Capsule Dynamic Analysis

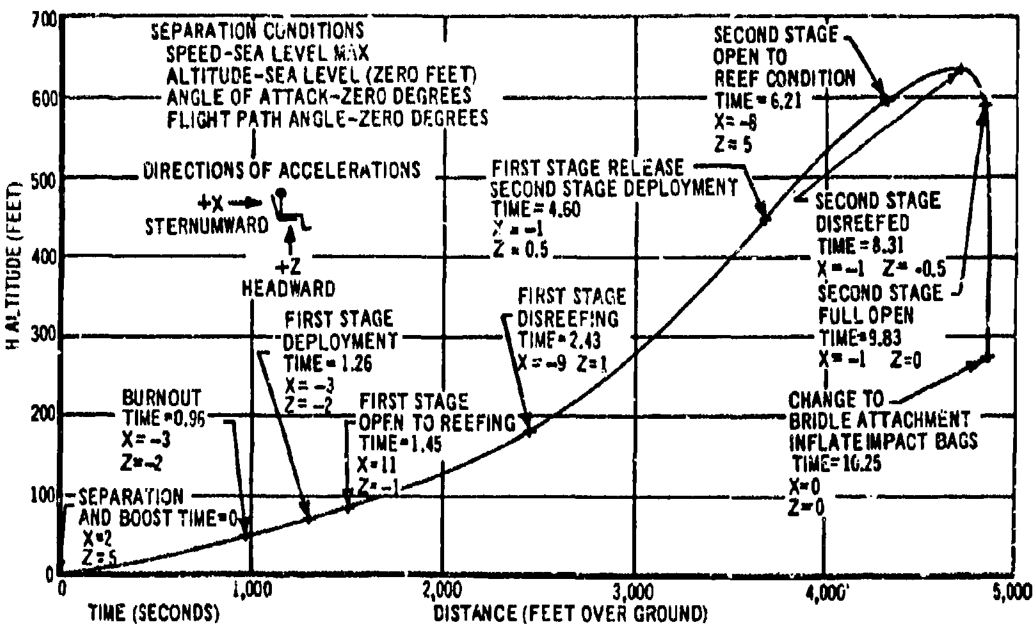


Figure 158. LTV Vought Aeronautics Integrated Flight Capsule High Speed Low Altitude Escape Sequence

parachute by a 35-foot deployment bridle to permit deployment beyond the capsule wake. The XM-1 ejector gun fires a one-pound slug at a nozzle velocity of 400 fps. The ejector gun performs two functions, it unlatches the main and pilot parachute doors and extracts the pilot chute. The delay initiators, dual for reliability, that supply gas pressure to fire the ejector gun are initiated as the capsule leaves the sled. The time delay was varied for each test so the recovery system was never initiated until capsule velocity was below 350 knots. The main parachute suspension lines are connected to the capsule by four steel risers as a precaution against high temperatures and blast from the rocket motor exhaust during separation. Two of the cables are attached below the parachute compartment on the rear bulkhead and the other two are attached to the underside of the upper stabilization wedge. The length of the cables is such that the parachute opening shock passes through the capsule center of gravity.

During the test program the escape system was initiated at a specified track station as the rocket-propelled sled reached the test velocity. Initiation was accomplished by simultaneously firing the two pyrotechnic squibs connected to each of the four explosive nuts and to the XM-15 rocket motor igniter. Upon capsule separation the two delay initiators, that actuate the XM-1 two second delay pilot chute ejector gun, are armed by pull rods attached to the sled. After a specified delay the ejector gun fires, opens the parachute compartment door, and deploys the pilot chute. The pilot chute inflates and extracts the main parachute bag. After the main parachute lines are fully stretched, the bag is pulled off and canopy inflation begins. For the tests, reefing lines were used in the main parachute, disreefing was accomplished with reefing line cutters utilizing a 1.7-second delay cartridge.

Figure 159 shows the test configuration including the nose capsule, track sled with fuselage, and rocket pusher sled. The first test was a horizontal static ejection conducted on 19 September 1962 at AFFTC, Edwards AFB, California. Subsequent testing was also conducted to demonstrate the system at track speeds of 100, 300, 500, 700 and 900 KEAS and from a vertical static position. The 900 KEAS test was attempted; however, structural failure allowed the capsule and afterbody to leave the sled prior to capsule release, and the test equipment was destroyed. This test was later attempted on the Naval Ordnance Test Station Track at China Lake, California, and another failure was experienced. The slippers failed, resulting in the destruction of the pusher sled. The escape capsule was not damaged and was used when the test was rerun at a later date. (This time the lower left wedge failed during capsule separation and the capsule was destroyed.) A summary of the F-104 capsule track test program is shown in Table XXX and the test trajectories are shown in Fig. 160. It was concluded that this program has demonstrated that the separable nose capsule escape system concept is feasible and that successful escape is possible at high dynamic pressures and low altitude.

Table XXX. Summary of Ejectable Nose Capsule Track Test Program

Run No.	Test Date	Temp (°F)	Pressure (In Hg)	Wind	Capsule No.	Trimmer Area (Ft^2)	Capsule Weight (Lb)	* Test Velocity (KEAS)	Rocket Thrust Moment Arm (Inches)	** Horizontal Distance (Ft)	*** Maximum Altitude (Ft)	Ejector Firing Delay (Sec)	Remarks
1	10 Aug 62	71	27.640	225°/5KN	2	1.5	2401	610	0.35	----	---	---	Calibration Run
2	19 Sept 62	92	26.670	225°/9KN	1	1.5	2416	Static Horiz.	0.25	470	154	2	Parachute Deployed Prematurely - Capsule Successfully Recovered
3	9 Oct 62	60	27.595	45°/4KN	1	1.5	2404	110	0.25	2032	184	3	Chute Approx. 70% Inflated - Minor Damage to Capsule
4	31 Oct 62	67	27.727	120°/8KN	2	1.5	2413	521	0.25	4750	156	5	Chute in Reefed Condition at Impact - Capsule Destroyed
5	8 Nov 62	61	27.725	Calm	3	1.5	2406	857	0	----	---	---	Calibration Run
6	11 Dec 62	--	---	---	3	1.5	2465	252	1.90	----	---	---	Programmed Velocity not Reached
6A	11 Dec 62	59	27.665	360°/5KN	3	1.5	2465	290	1.90	2673	282	2	Complete Success - No Damage
7	11 Jan 63	37	27.590	90°/8KN	3	4.0	2437	511	2.00	6100	598	4	Ejector Bridle Failed - No Chute Deployment
8	1 Feb 63	63	27.710	225°/20KN	4	3.3	2466	721	2.00	5964	596	6	Complete Success
9	14 Mar 63	64	27.485	225°/17KN	5	3.0	2415	777	2.00	----	---	7	Sled Structural Failure
10	18 Apr 63	54	27.619	270°/16KN	1	1.5	2420	Static Vert	0	375	395	2	Successful

* Corrected for wind

** Measured from rocket motor firing point

*** Measured from capsule CG

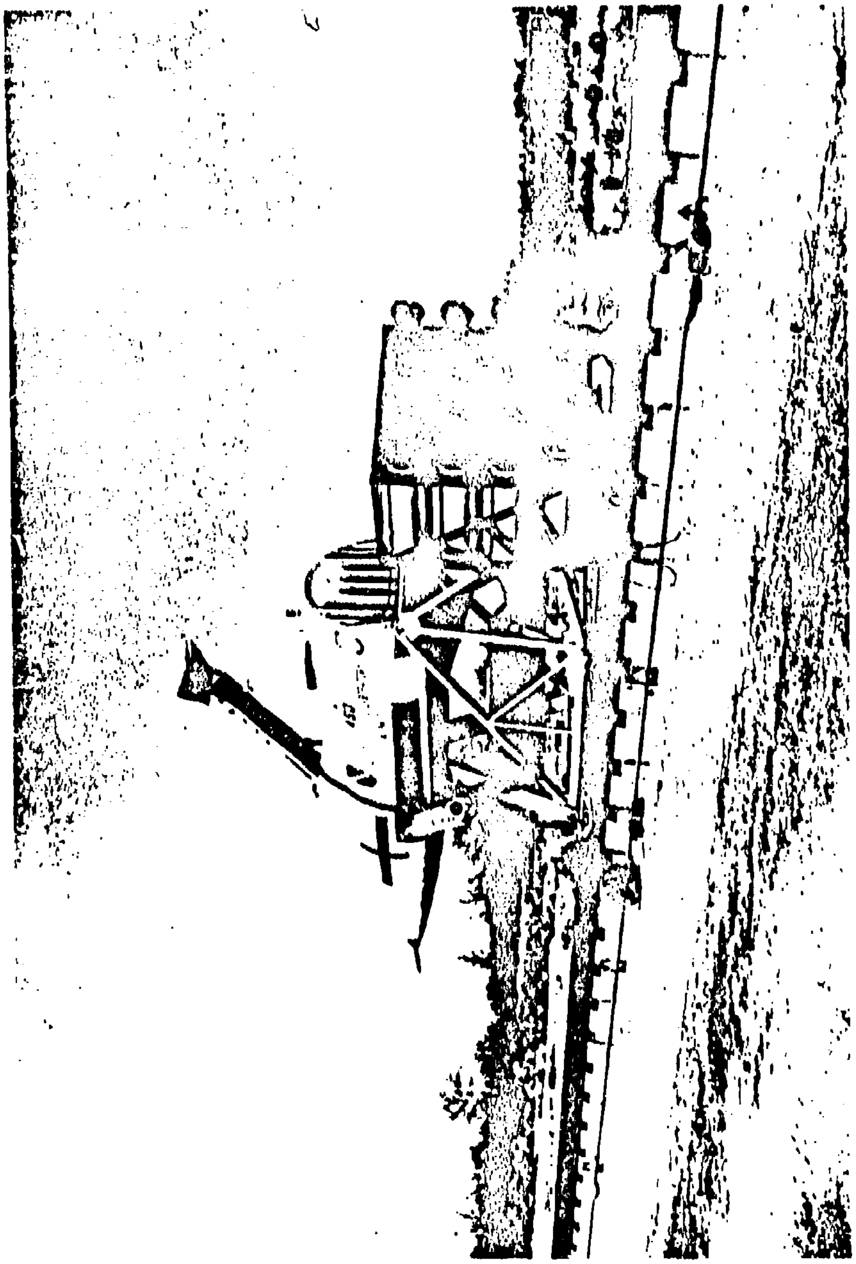


Figure 159. Lockheed F-104 Capsule-Track Sled-Rocket Pusher Sled

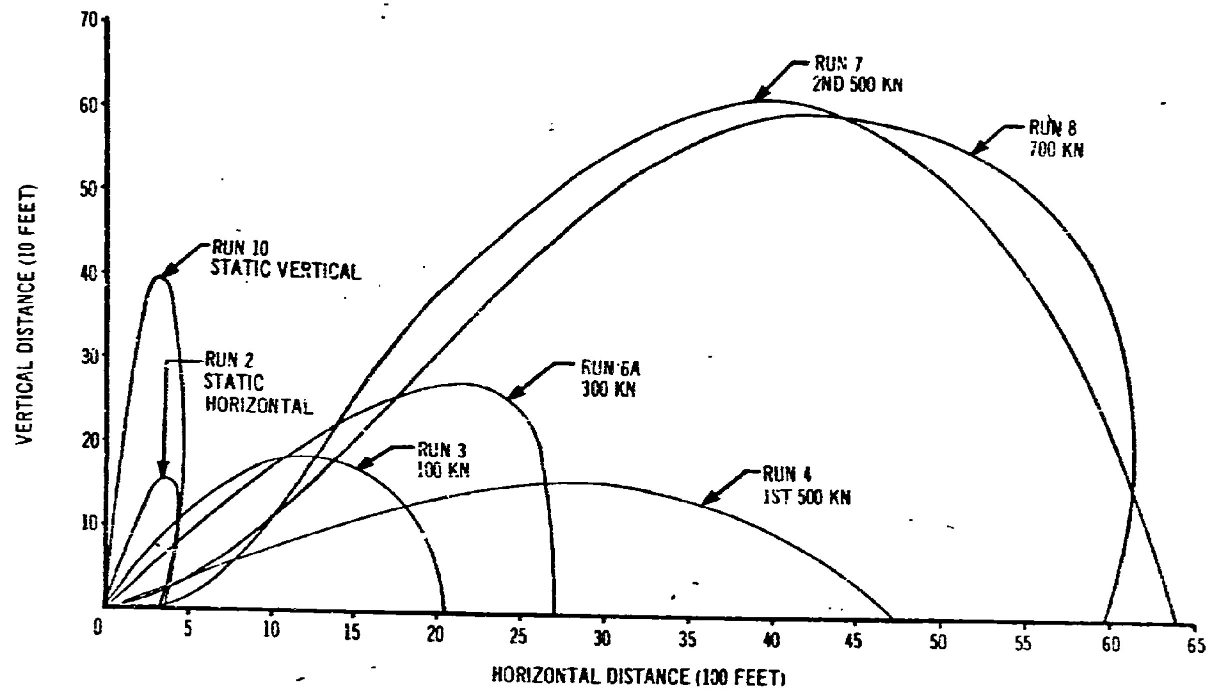


Figure 160. Lockheed F-104 Capsule Test Trajectories

c. VERTOL H-25 SEPARABLE CAPSULE

The Vertol Division of The Boeing Company conducted a study to determine the requirement and also the feasibility of a helicopter escape system. The study definitely established the requirement for an escape system by showing that approximately 56 percent of Navy helicopter occupant fatalities, during the 1952-1960 period, occurred in emergencies demanding inflight escape as the only means of survival. The study also indicated the capsule concept, rather than manual bailout or ejection seats, will be the most suitable escape system. A comparison of the systems showed the capsule will offer a safer system in view of the rotor hazard, will allow a passive role for the passengers, will be lighter in weight, and will be effective at altitudes above 100 feet at hover and/or cruising speeds.

A capsule escape system program was initiated by the Bureau of Naval Weapons to design, develop, and test demonstrate a fuselage capsule escape system for possible use in future helicopters. The UH 25B (formerly HUP2) Twin-Rotor Navy Helicopter was chosen as the test vehicle due to its recent retirement from service and its availability in the quantity required for this program. Some of the ground firing tests and all of the planned droning tests will result in the destruction of the test vehicle.

The escape system's major components are the forward fuselage section, initiation and separation system, aft fuselage rocket system, and the parachute system. Structural modification of the HUP2 helicopter consisted of the following:

- A bulkhead was added to enclose the capsule and to provide strong points for the rear attachments of the parachute bridle.
- A special fitting was inserted into the front hoist fitting to provide forward attachment of the parachute bridle.
- Two canisters were fitted in the cabin area (capsule portion) to accommodate the four ballistic parachutes.
- Mounting brackets were fitted on both sides of the rear fuselage for the separation rockets.

Various ballistic components and subsystems are employed to separate the capsule from the aft fuselage as follows:

- Fuselage structure separation is accomplished by a continuous ring linear-shaped charge with conical-shaped charges fitted into the four longerons.
- The transmission midshaft cutting device consists of a linear-shaped charge ring mounted close to the shaft.

- Services including oil lubrication lines, electric cable bundles, and steel control cables are severed by 32 ballistically operated guillotines.

- The rotor shafts are cut with a linear-shaped charge ring employing an energy transfer slip-ring to initiate the blade separation charges. Four of the flapping hinge pins are fitted with internally located explosive charges to release the blades as the shaft is severed. The third blade remains attached and carries each rotor away from the helicopter.

- The separation rockets (P6M-1100 lb-sec) mounted on the aft fuselage thrust toward the rear and downward to move it away from the escape capsule.

Recovery of the capsule is accomplished by four ultra-fast-opening parachutes developed by Stencel Aero Engineering Corporation. The 35-foot parachutes are ballistically deployed from the upper and lower portion of the two capsule-mounted canisters 0.6 second after escape system initiation. After the parachutes are fully deployed (line stretch), the canopies are instantly opened by ballistic spreader charges, a feature of the UFOP parachute.

Development testing has been completed on the capsule subsystems, including drop testing of the H-25 capsule to demonstrate the recovery system. A complete system demonstration utilizing a tied-down helicopter, as shown in Fig. 161, was also accomplished. Figure 162 shows the separation system and aft rocket initiation. Firing the linear-shaped charges severs the rotors and blades, and separates the capsule from the aft fuselage as shown in Fig. 163. After rocket burnout the parachute deployment mortars are fired. Figure 164 shows the parachute bags emerging from the capsule canisters. The parachutes are ballistically spread upon reaching full deployment, as shown in Fig. 165. For the test, the two lower portions of the canisters were fitted with dummies to simulate the mass and react the explosive deployment charge.

Further testing of the system is tentatively planned for 1966. The tests will consist of full-scale capsule drops from a C-130 to demonstrate the recovery system and also droning tests of the complete system. It is anticipated that the development of the Stencel automatically-reefed parachute will be completed and incorporated into the capsule system for these tests.

d. BOEING ADO-12 SEPARABLE NOSE CAPSULE

The ADO-12 separable nose capsule escape system was designed to provide safe escape during flight conditions from zero-speed to Mach 1.2 at zero-altitude and up to Mach 3.0 at 70,000 feet. Figure 166 shows a block diagram of the sequence of events, and Fig. 167 is a pictorial representation of this sequence. If escape is initiated above 15,000 feet, a baroswitch prevents recovery parachute deployment until the capsule descends to 15,000 feet.

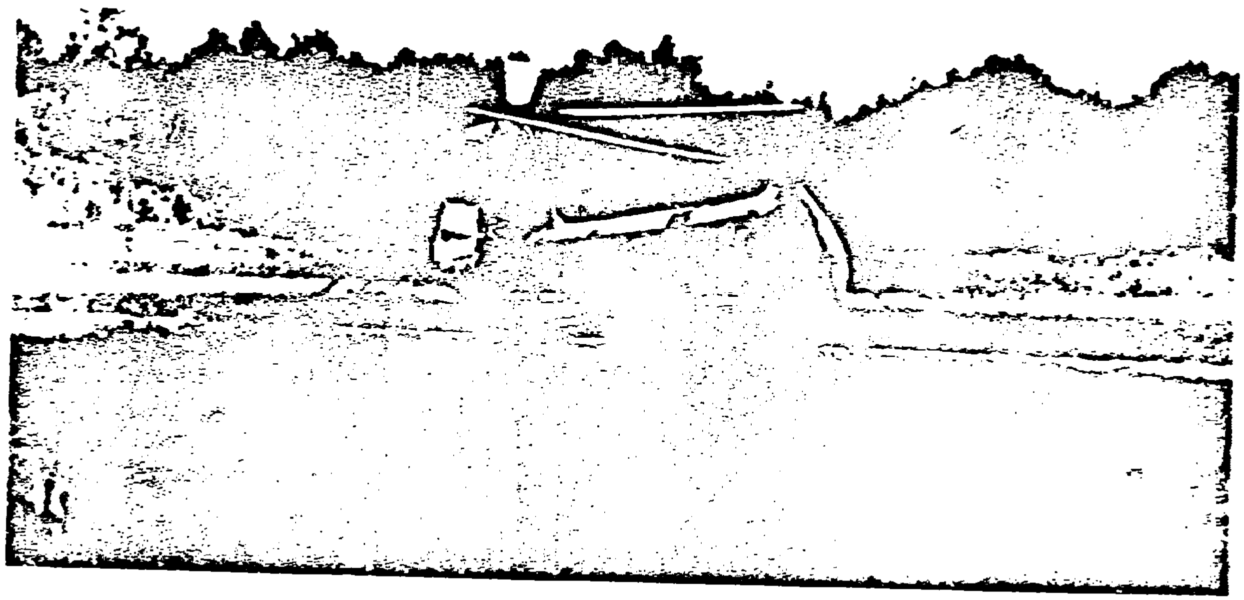


Figure 161. H-25 Helicopter Capsule Test Configuration

Figure 162. H-25 Helicopter Capsule Separation System Initiation

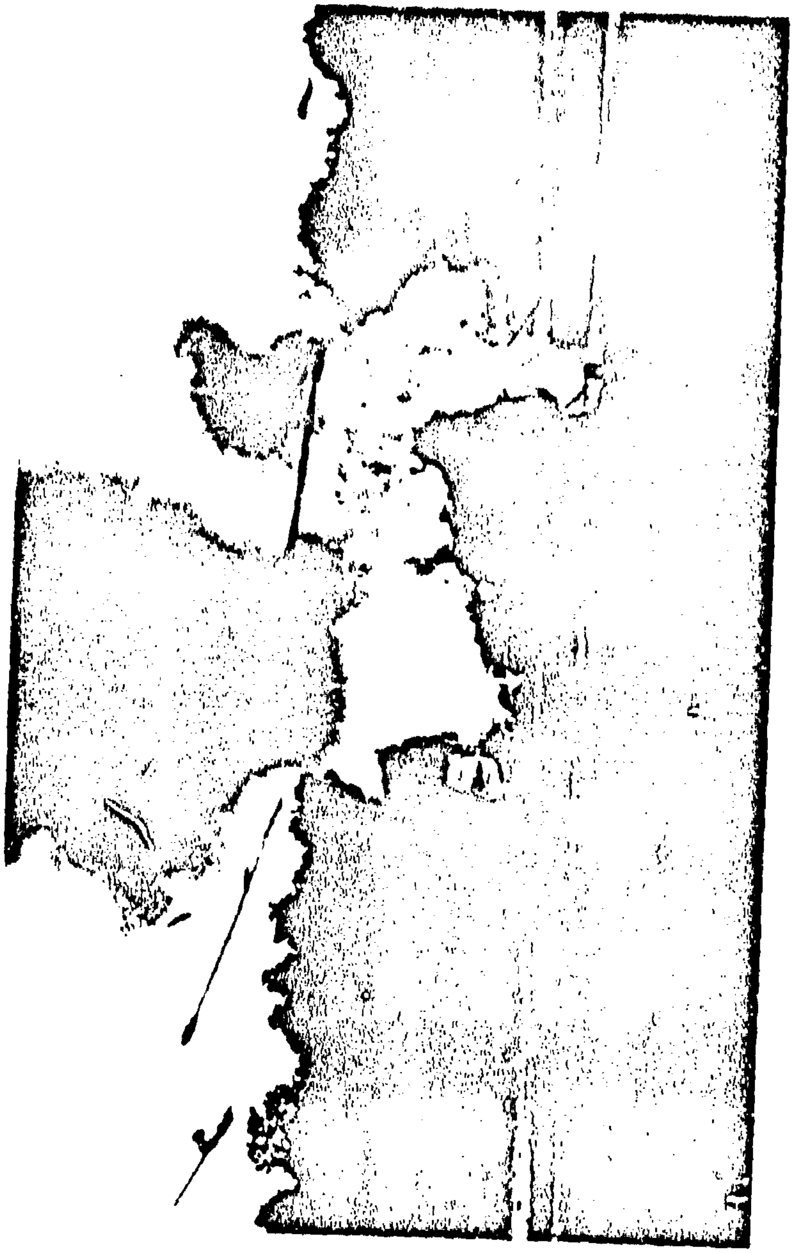


Figure 163. H-25 Helicopter Capsule Rotors and Capsule Separation

Figure 164. H-25 Helicopter Capsule Parachute Deployment

Figure 165. K-25 Helicopter Capsule Parachute Ballistically Spread

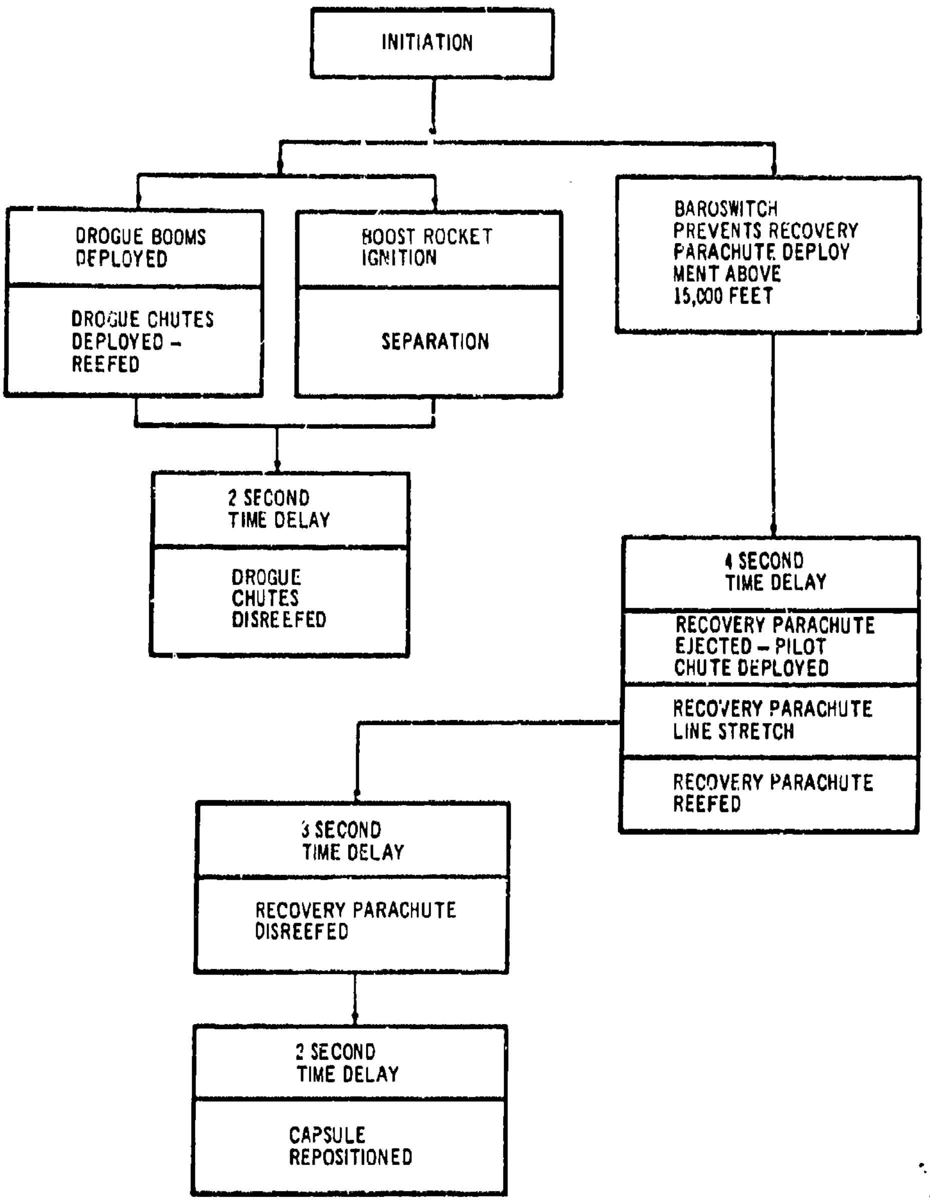


Figure 166. Boeing ADO-12 Separable Nose Capsule Escape System

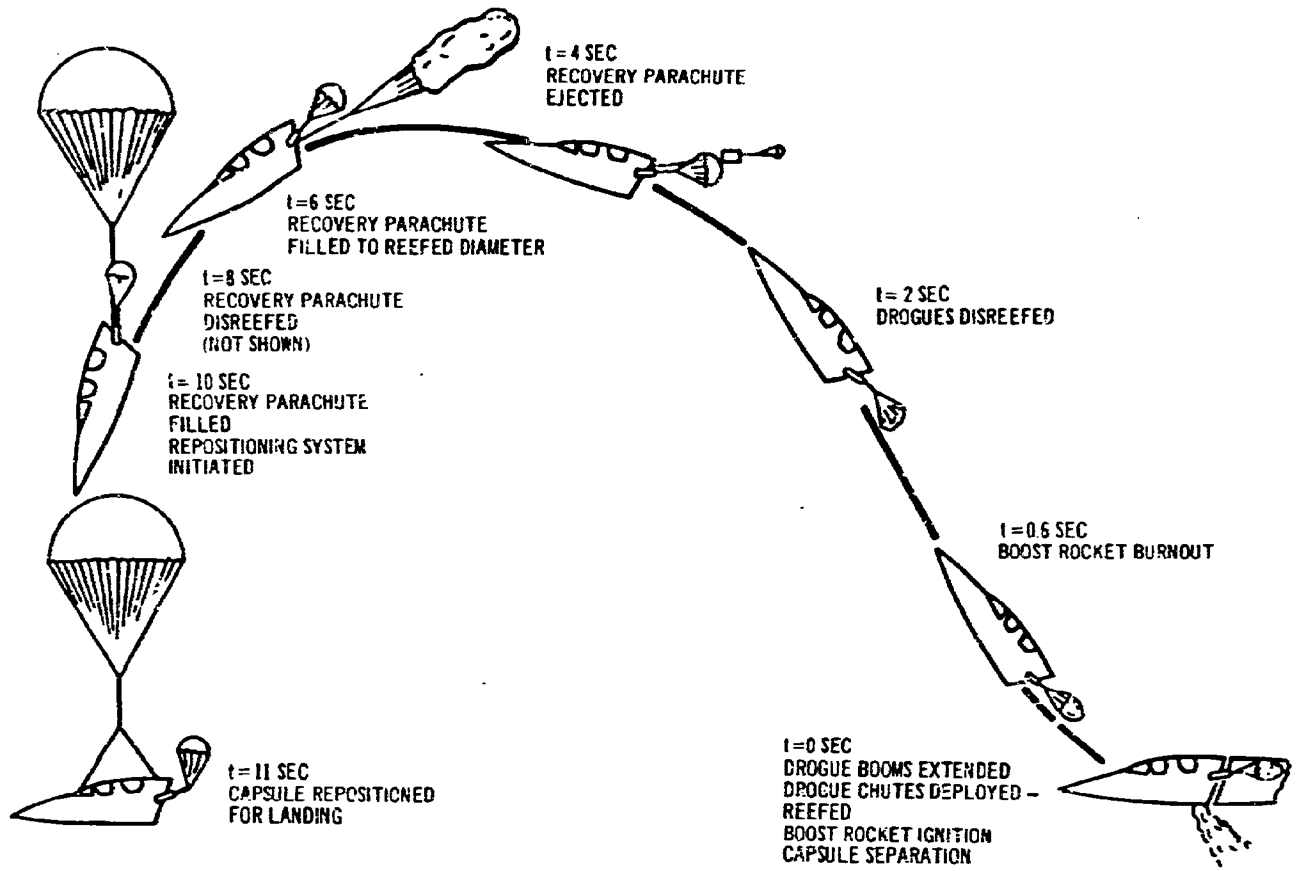


Figure 167. Boeing ADO-12 Seperable Nose Capsule Escape and Recovery Sequence

The following is a description of the system and sequence of operation for escape below 15,000 feet:

- Telescoping propellant actuated drogue parachute booms are extended outward and aft from either side of the capsule.
- A six-foot diameter conical ribbon stabilization/deceleration parachute is deployed, reefed to four feet, from each drogue boom. These reefed drogues provide necessary capsule stability.
- A 68,000-pound thrust, 0.6-second burning time solid propellant boost rocket is ignited. The rocket thrust is directed forward and upward through the capsule center of gravity.
- Linear-shaped charge severs the airplane structure, wire bundles, cables, ducts, etc., separating the nose capsule from the airplane afterbody.
- After a two-second time delay from capsule separation, the stabilization and deceleration drogues are disreefed to their full six-foot diameter. These disreefed parachutes provide rapid deceleration of the capsule to safe deployment speeds for the main recovery parachute.
- After a four-second time delay from separation, a 74.2-foot diameter ringsail main recovery parachute is mortar ejected and deployed by pilot chute.
- The main recovery parachute inflates to a reefed diameter of 5.5 feet. After a time delay of three seconds from parachute line stretch, the main recovery parachute is disreefed.
- Two seconds after main parachute disreef, the capsule is reoriented to a near horizontal attitude for landing.
- After water landing, flotation cells are automatically deployed and inflated.

The major subsystems incorporated in the separable nose capsule are: separation system, boost rocket system, stabilization/deceleration system, recovery system, and landing and flotation system. The following is a functional description of the subsystems and the general arrangement of the escape system components, as shown in Fig. 168.

The nose capsule is separated from the airplane along a diagonal line aft of the rear cockpit pressure bulkhead, as shown in Fig. 168. Separation is accomplished after the boost rocket has built up to a maximum thrust to assure forward motion of the capsule when escape is initiated during high-speed, high-drag conditions. The time required for the rocket to reach maximum thrust is approximately 0.05 seconds. Gas pressure from the rocket enters two separation manifolds and ignites mild detonating cords that lead to a series of linear-shaped charge segments. Detonation of the linear-shaped charge segments

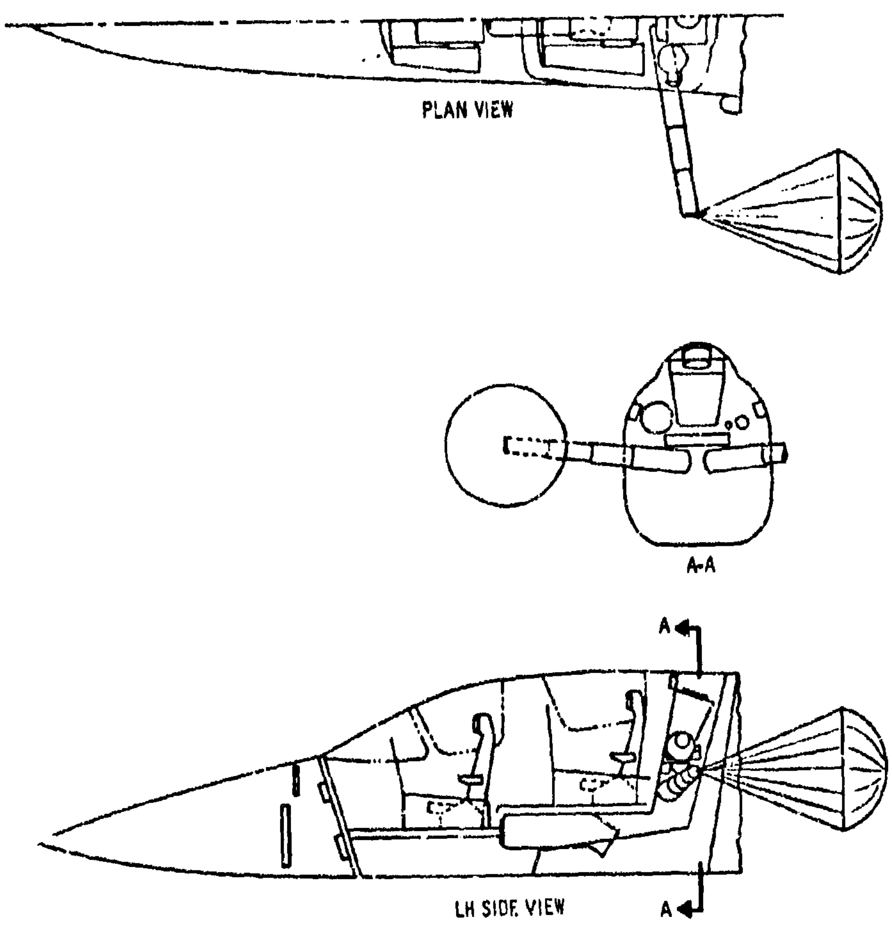


Figure 168. Boeing ADO-12 Separable Nose Capsule – General Arrangement and Installation of Capsule Escape System Compartments

severs the airplane fuselage skin, longerons, wire bundles, air conditioning ducts, and control cables that pass through the separation plane. The rocket thrust immediately pushes the escape capsule away from the airplane.

The boost system consists of a solid propellant rocket motor of 68,000 pounds average thrust and a burn time of 0.6 second. The rocket thrusts forward and upward through the capsule center of gravity at an angle of 34 degrees to the capsule horizontal axis. The rocket is sized to provide sufficient horizontal thrust to separate the nose capsule from the airplane afterbody at the maximum dynamic pressure condition of 800 knots EAS. The vertical thrust component is based on trajectory height requirements for ground level recovery at all speeds from zero to Mach 1.2 at sea level. The angle of thrust and total thrust was established by the resultant of vertical and horizontal thrust vectors.

Capsule stabilization and deceleration functions are integrated into a single system. Cartridge actuated booms are deployed upward and aft from either side of the capsule prior to separation, as shown in Fig. 168. Initial vertical and lateral stabilization is accomplished by deploying a reefed conical ribbon parachute from the end of each boom at the time of separation. Disreefing of the parachutes provides necessary capsule deceleration prior to the deployment and filling of the recovery parachute. The conical ribbon parachutes of the size and loading capacities required have the advantage of a low supersonic drag coefficient (0.31) and a larger subsonic drag coefficient (0.46).

Since the stabilizing forces must be applied to the capsule during separation, the boost rocket must provide sufficient thrust to overcome the additional drag of the reefed parachutes. Figure 169 shows the effect on rocket thrust and weight requirements of various reefed parachute sizes. It may be noted that the boost rocket weight must be increased by 74 pounds in order to accommodate the minimum effective drag area required for stabilization. This additional rocket weight is justified because the combined weight of the stabilization/deceleration and boost system, as designed, is substantially less than if aerodynamic surface stabilization and separate deceleration systems are used.

Rapid deceleration of the escape capsule from high escape speeds to safe main recovery parachute opening speeds is required for effective low level/dive escapes. However, deceleration rates must be compromised by human tolerance, practical structural and weight considerations, and time sequencing that is compatible with zero-speed, zero-altitude escape. To provide the required deceleration, the stabilization/deceleration parachutes are disreefed from the four-foot diameter to a full diameter of six feet. To establish the optimum disreefing time, performance computations were made at the critical recovery condition of 800 KEAS at 15,000-feet. Figure 170 shows the effect of various disreefing times on the decrease of

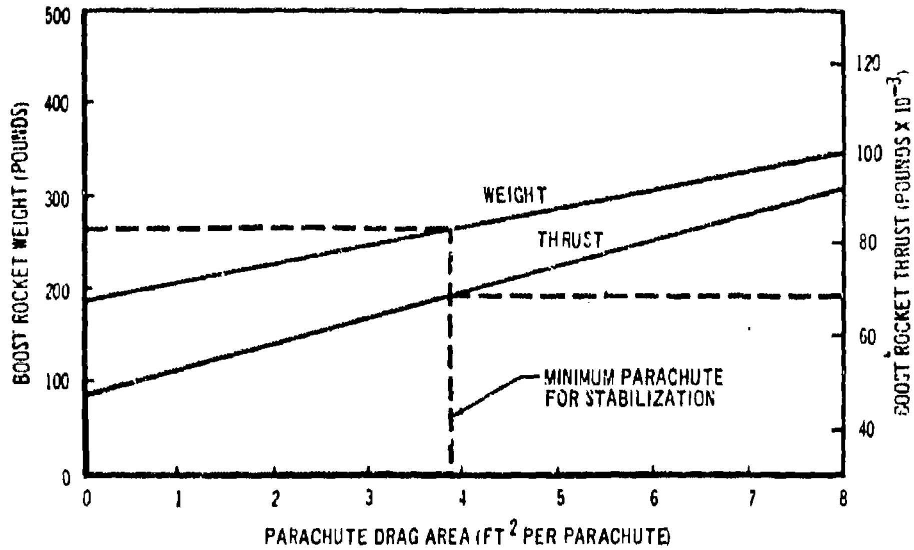


Figure 169. Boeing ADO-12 Separable Nose Capsule – Stabilization/Deceleration Parachute Drag Area

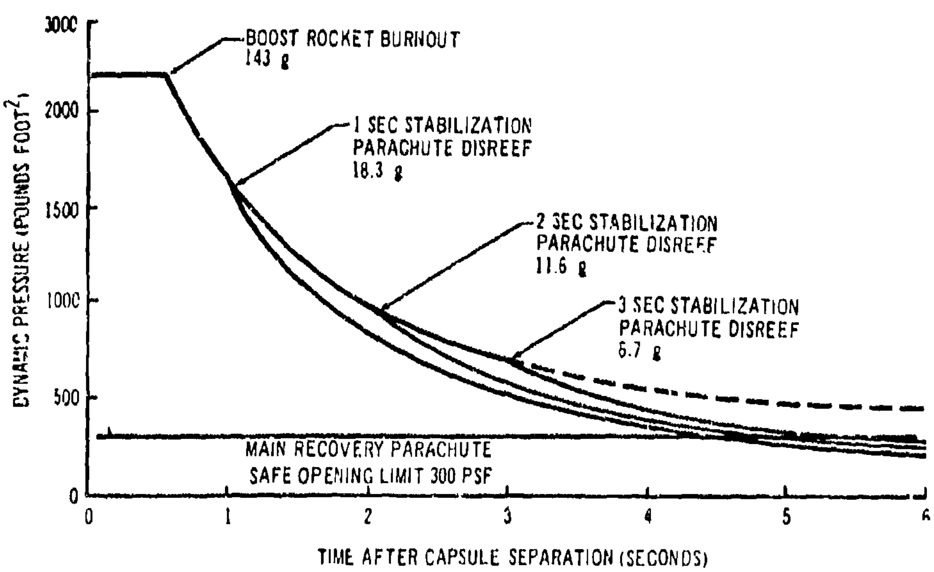


Figure 170. Boeing ADO-12 Separable Nose Capsule – Dynamic Pressure Decay

dynamic pressure (q) as the capsule is decelerated to the main recovery parachute safe opening speed (equivalent to a q of 300 psf). The two-second reefing time was selected because it provides the least time delay required to reach recovery parachute opening speed, while maintaining the disreefing deceleration peak within reasonable limits (11.6g). The one-second disreefing was not used because the capsule deceleration upon disreefing would peak to 18.3g. This would require a greater parachute strength than is compatible with the reefed strength requirements and would have resulted in a higher parachute weight than the selected system.

The recovery system consists of a single 74.2-foot diameter ringsail parachute. This parachute opens considerably faster than large solid cloth canopies and can compete with smaller canopies such as would be required in an equivalent cluster. Further, the single fast opening parachute can satisfy the performance requirements with less weight and lower design loads.

For escapes below 15,000-foot altitude (baroswitch prevents recovery parachute deployment at higher altitude), the recovery parachute pack is forcibly ejected four seconds after separation of the capsule from the aircraft. Since parachute deployment to line stretch requires approximately one second, a total of five seconds elapses prior to line stretch. This allows the capsule to reach the apogee of its trajectory, and to decelerate to the safe parachute opening speed, when escape is initiated at the critical condition of 800 KEAS at 15,000 feet.

The recovery parachute is reefed to 7.5 percent of the full diameter for three seconds from canopy line stretch. Upon disreefing, the recovery parachute completes inflation and retards the capsule velocity to a 30-foot per second sea level rate of descent. After a two-second time delay from recovery parachute disreef, the capsule is automatically reoriented to a near horizontal attitude. This landing attitude eliminates tumbling during landing on rough terrain and ground wind conditions. Cockpit volume provides sufficient displacement for capsule flotation. However, inflatable flotation cells are used to provide adequate free-board and stability.

A 7090 IBM computer program, "Cockpit Capsule Escape System Dynamic Analysis — Six Degrees of Freedom," was utilized to analyze the capsule flight characteristics after escape initiation. However, due to the limited amount of nose capsule wind tunnel data available, the computer program calculations were restricted to the pitch plane and a three degrees of freedom performance analysis.

Results of the analyses are summarized in Figs. 171, 172, and 173 showing the appropriate capsule trajectories and subsystem sequence of operation for simulated runway escapes, spinal and transverse accelerations for maximum speed at the critical altitudes and the effects of the subsystems operation timing sequence, and capsule angle of attack from capsule separation through recovery.

Table XXXI gives the weight breakdown of the capsule.

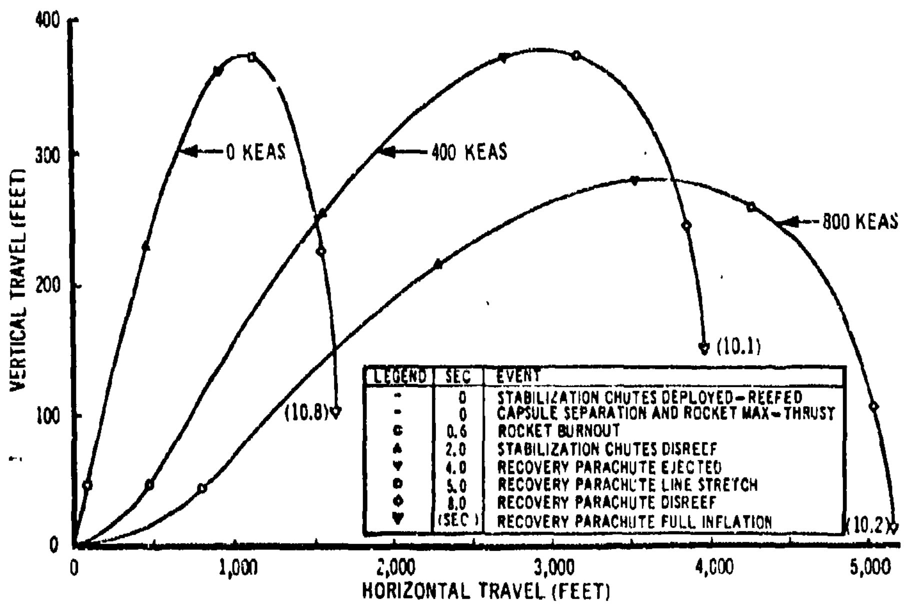


Figure 171. Boeing ADO-12 Separable Nose Capsule Trajectories and Calculations (Sea Level)

LEGEND	SEC	EVENT
—	0	STABILIZATION CHUTES DEPLOYED–REEFED
—	0	CAPSULE SEPARATION AND ROCKET MAX THRUST
○	0.6	ROCKET BURNOUT
△	2.0	STABILIZATION CHUTES DISREEF
▽	4.0	RECOVERY PARACHUTE EJECTED
□	5.0	RECOVERY PARACHUTE LINE STRETCH
◇	8.0	RECOVERY PARACHUTE DISREEF
▽	(SEC)	RECOVERY PARACHUTE FULL INFLATION

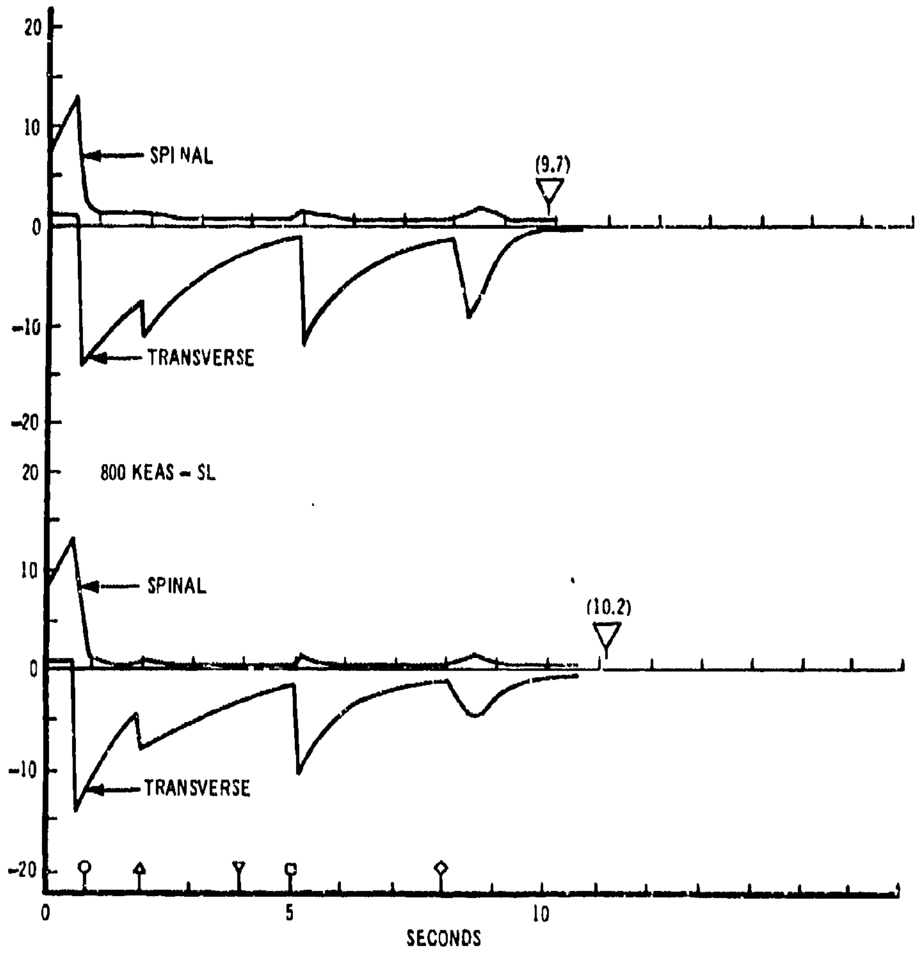


Figure 172. Boeing ADO-12 Separable Nose Capsule Calculated Capsule CG Accelerations

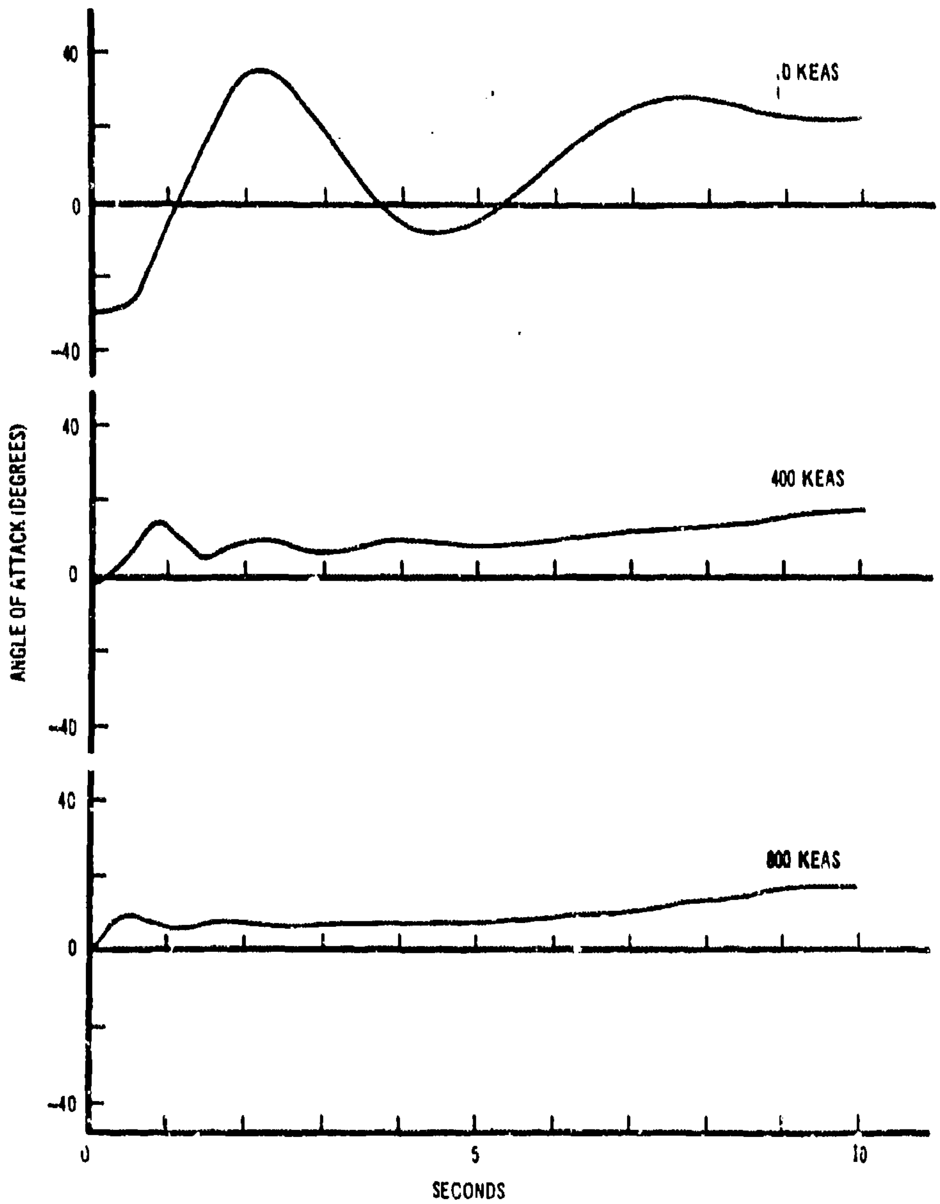


Figure 173. Boeing ADO-12 Separable Nose Capsule Angle of Attack versus Time (Sea Level)

Table XXXI. ADO-12 Weight Breakdown

	Volume (Cu In)	Weight (Lb)	
Controls and Initiation System			
Primary firing controls	--	6.5	
Alternate separation controls	--	2.0	
Pressure actuated initiator	--	2.0	
			10.5
Separation System			
Separation system initiation manifolds	--	1.2	
Linear-shaped charge	--	12.5	
			13.7
Boost Rocket			
Rocket motor	5702	264.0	
Support structure	--	25.0	
			289.0
Stabilization/Deceleration Parachute System and Controls			
Booms	3020	136.6	
Parachutes	2000	20.0	
			156.6
Recovery System and Controls			
Recovery parachute	5500	125.0	
Aneroid controls		2.0	
Bridle		7.0	
Chute disconnect		.5	
Repositioning controls and bridle		9.7	
Support structure		33.0	
			177.2
Flotation System			
Cool gas generators		20.5	
Cells and stowage provisions		30.5	
			51.0
Emergency Pressurization System			
2,000 psi flask, regulator, lines and attachments		24.0	
			24.0
Survival Equipment		85.0	
			85.0
	Total weight		807.0

e. BOEING SUPERSONIC SEPARABLE NOSE CAPSULE

The Boeing separable nose capsule escape system is the result of a design study. It comprises the forward fuselage section of a supersonic airplane and is an integral part of the basic airframe. The system provides safe escape for a side-by-side, two-man crew during flight conditions from zero speed to Mach 1.2 at zero altitude; up to Mach 2.5 at 60,000 feet. Underwater escape is also provided. The escape system performance envelope is shown in Fig. 174, the general arrangement in Fig. 175, and a side profile of the capsule in Fig. 176.

In the event of an inflight emergency, actuation of either crew member's primary firing control initiates a completely automatic escape sequence which ignites the boost rocket. Gas pressure from the boost rocket initiates the separation, deceleration, and recovery systems. The nose capsule is separated by linear-shaped charge installations adjacent to, or around, aircraft structure, skin, formers, control cables, wire bundles, lines, and all other components passing through the parting plane. Concurrent with escape initiation, the ballistic inertia reels, emergency radio beacon, pressurization, and emergency oxygen systems are actuated. The rocket motor boosts the nose capsule upward and away from the fuselage. As the nose capsule separates from the fuselage, two four-foot diameter fist ribbon stabilizing parachutes are deployed. One-quarter second after initiation, a 10-foot diameter fist ribbon deceleration parachute is forcibly deployed directly aft to sufficiently reduce the speed of the nose capsule permitting safe deployment of the recovery parachutes. Following descent to 15,000 feet, or in four seconds after initiation if below 15,000 feet, the deceleration parachute is jettisoned and two 63-foot diameter modified ring sail recovery parachutes are forcibly deployed. These parachutes are deployed in a reefed condition to further reduce the speed of the nose capsule and to ensure orderly inflation. After two more seconds, the reefing lines are cut and the recovery parachutes inflate to their full diameter. Full inflation occurs eight and one-quarter seconds after initiation. Two seconds after the recovery parachutes inflate, the nose capsule is repositioned to a nose-up suspension condition. Following descent, the recovery parachutes are manually disconnected to prevent dragging of the nose capsule. A system schematic is shown in Fig. 177.

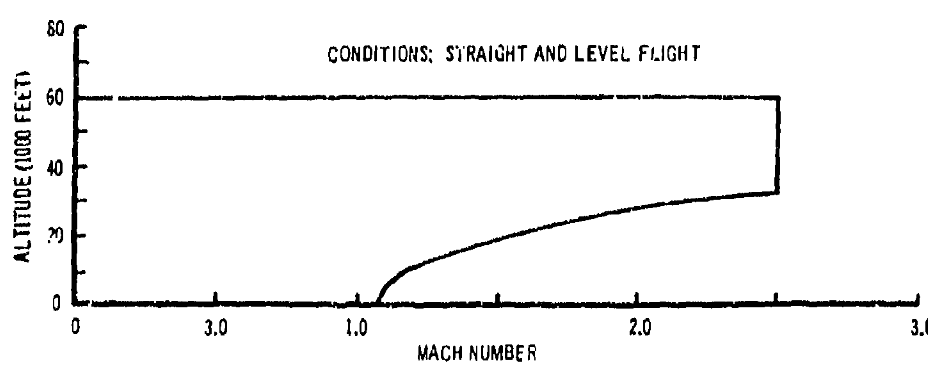


Figure 174. Boeing Supersonic Separable Nose Capsule – Performance Envelope

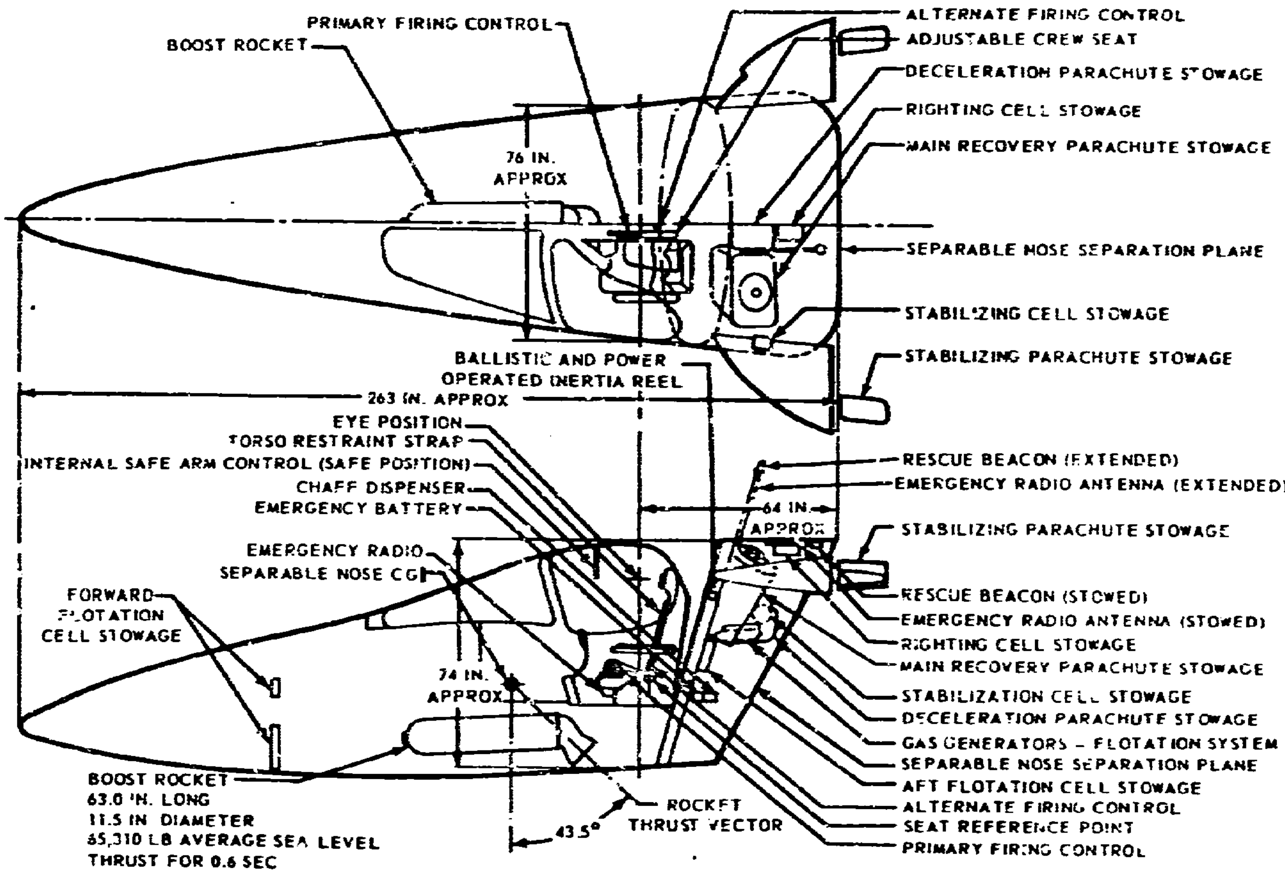


Figure 175. Boeing Supersonic Separable Nose Capsule – General Arrangement

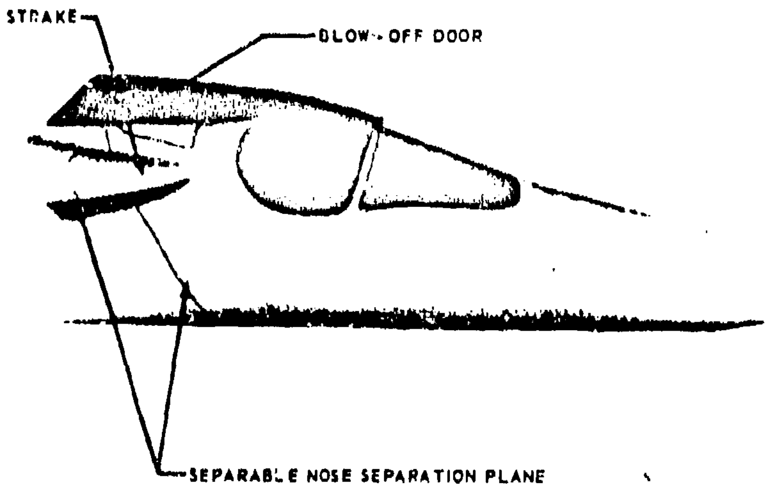
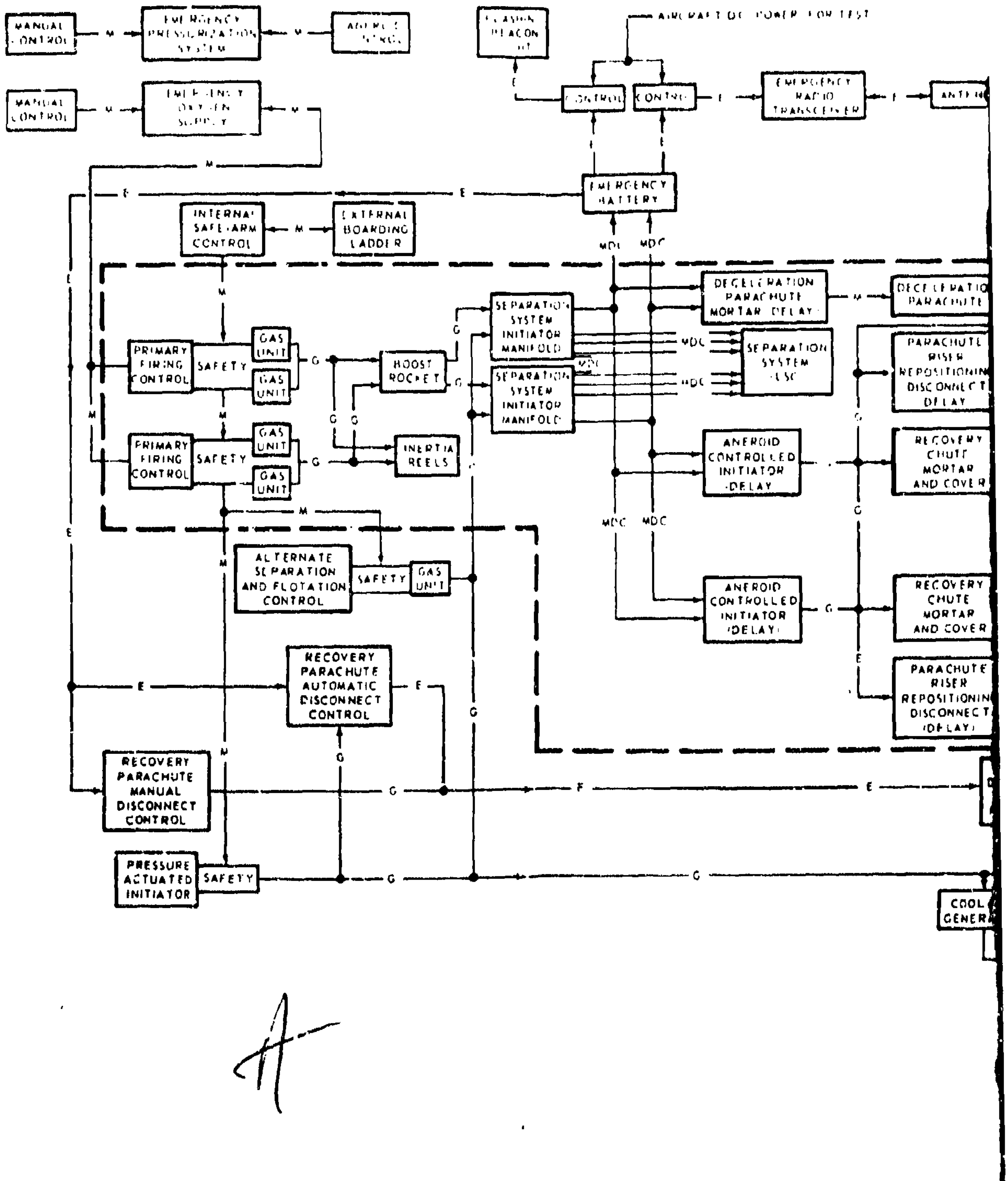


Figure 176. Boeing Supersonic Separable Nose Capsule – Right Side Profile

If the aircraft is submerged in water, the nose capsule is automatically separated from the aircraft. A water-pressure sensor set at 12 psi (26 foot depth) actuates a ballistic initiator to start the automatic sequence. The boost rocket is bypassed and only the separation, flotation, and rescue aids subsystems are actuated. Flotation cells inflate to stabilize the nose section and expedite ascent to the surface.

A time history of the escape sequence accelerations through recovery parachute inflation shows them to be within the specified limits of human tolerance as shown in Fig. 178. On ground landing, the nose capsule structure absorbs energy by crushing. This results in an average g-loading on the crewmen of 15g for 0.07 second. When landing in water, the nose capsule penetrates to a depth of approximately five feet and immediately rises and adopts a flotation attitude. Maximum loads on the crewmen during water entry are approximately 4g.

Table XXXII shows the Boeing supersonic separable nose escape system weight breakdown.



MANUAL CONTROL
EMERGENCY PRESSURIZATION SYSTEM
MANUAL CONTROL
EMERGENCY OXYGEN SUPPLY
BEACON
AIRCRAFT DC POWER FOR TEST
CONTROL
EMERGENCY RADIO TRANSCEIVER
EMERGENCY BATTERY
INTERNAL SAFE-ARM CONTROL
EXTERNAL BOARDING LADDER
PRIMARY FIRING CONTROL
SAFETY
GAS UNIT
BOOST ROCKET
INERTIA REELS
SEPARATION SYSTEM INITIATOR MANIFOLD
DECELERATION PARACHUTE MORTAR (DELAY)
SEPARATION SYSTEM
ANEROID CONTROLLED INITIATOR (DELAY)
RECOVERY CHUTE MORTAR AND COVER
ALTERNATE SEPARATION AND FLOTATION CONTROL
RECOVERY PARACHUTE AUTOMATIC DISCONNECT CONTROL
RECOVERY PARACHUTE MANUAL DISCONNECT CONTROL
PRESSURE ACTUATED INITIATOR
MDC

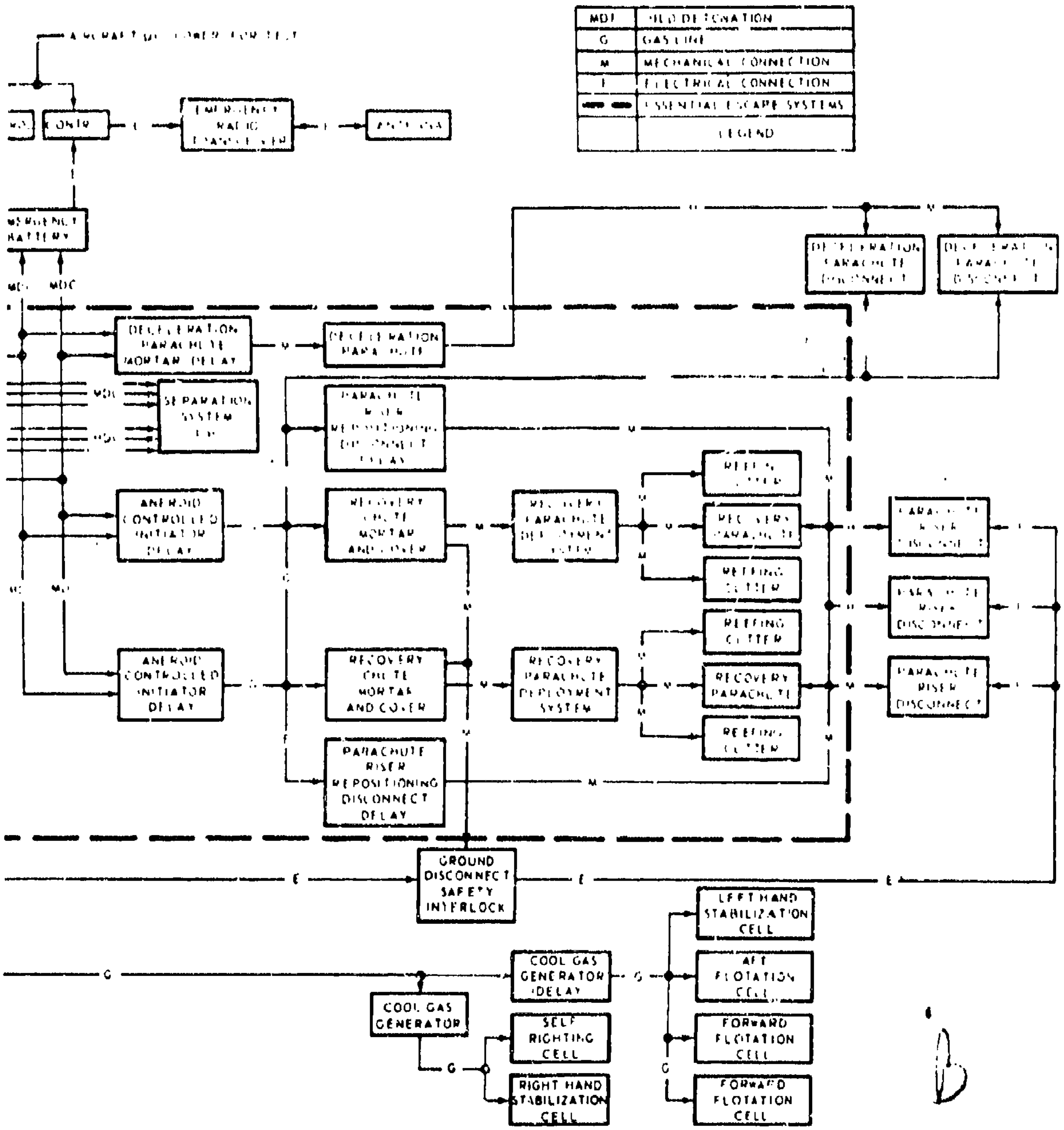


Figure 177. Boeing Supersonic Separable Nose Section System Schematic

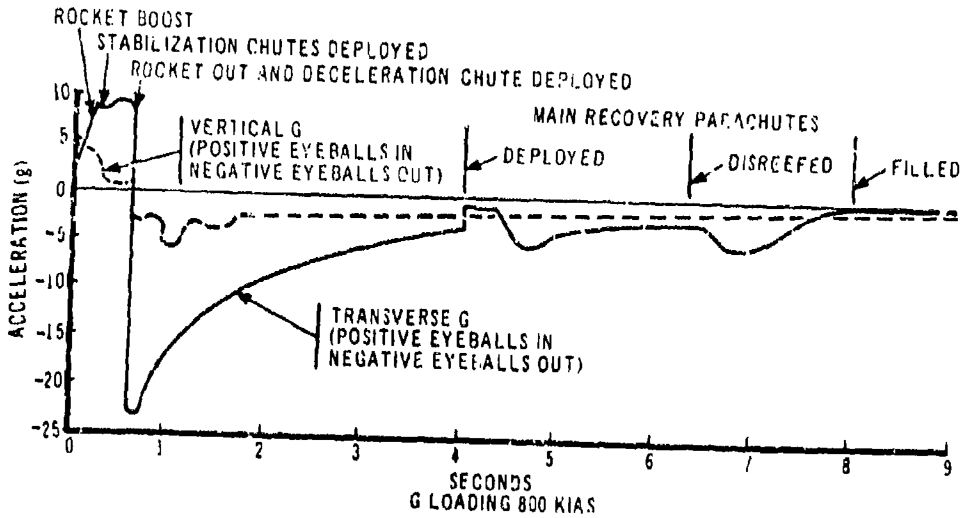


Figure 178. Boeing Supersonic Separable Nose Capsule - Acceleration Versus Time

Table XXXII. Boeing Supersonic Separable Nose Escape System Weight Breakdown

Item	Weight (Lb)
Adjustable seat, including inertia reels and restraint harness	110
Survival and rescue equipment, including battery, radio, beacon light, and chaff dispenser	
Controls and initiation system	85
Separation system	13
Boost rocket	16
Boost rocket support structure	263
Flotation system	25
Recovery system and controls	52
Recovery system attach fittings	250
Emergency pressurization system	18
Crew (less personal equipment)	24
Crew oxygen provisions	400
Personal equipment	20
	30
Total	1,306

Yaw time histories for sea level escape conditions encompassing the critical speed range are shown in Fig. 179. The angle-of-attack curves for various speeds are shown in Fig. 180.

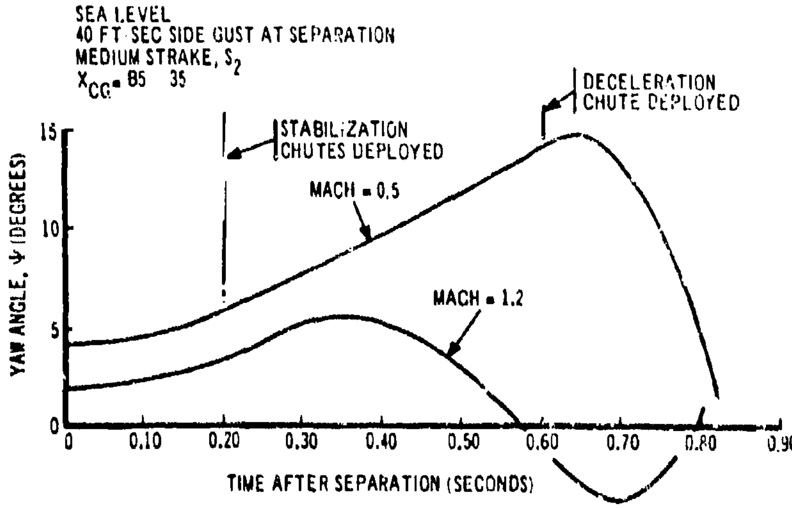


Figure 179. Boeing Supersonic Separable Nose Capsule – Yaw Time Histories for Sea Level Escape

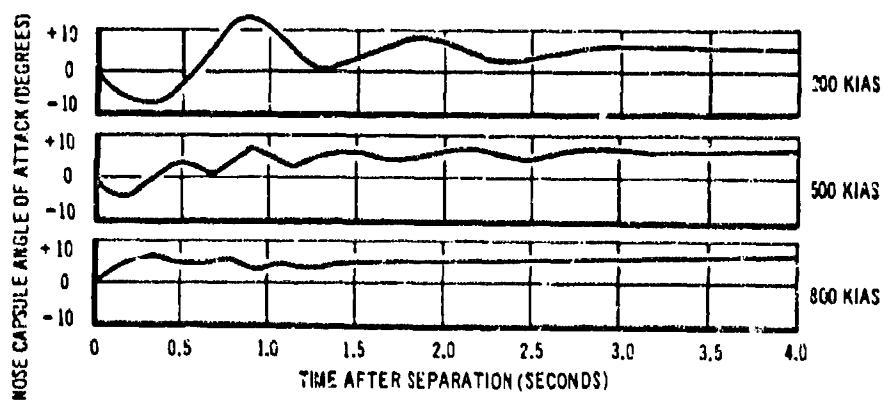


Figure 180. Boeing Supersonic Separable Nose Capsule – Dynamic Stability Characteristics

Trajectory analysis of the separable nose capsule during the escape period shows that successful recovery will be made at all speeds from zero to 800 KIAS as shown in Fig. 181. Adequate clearance of the separable nose capsule from the aircraft is attained at all airplane speeds. The trajectory of the separable nose capsule over the airplane for the 800 KIAS condition is shown in Fig. 182.

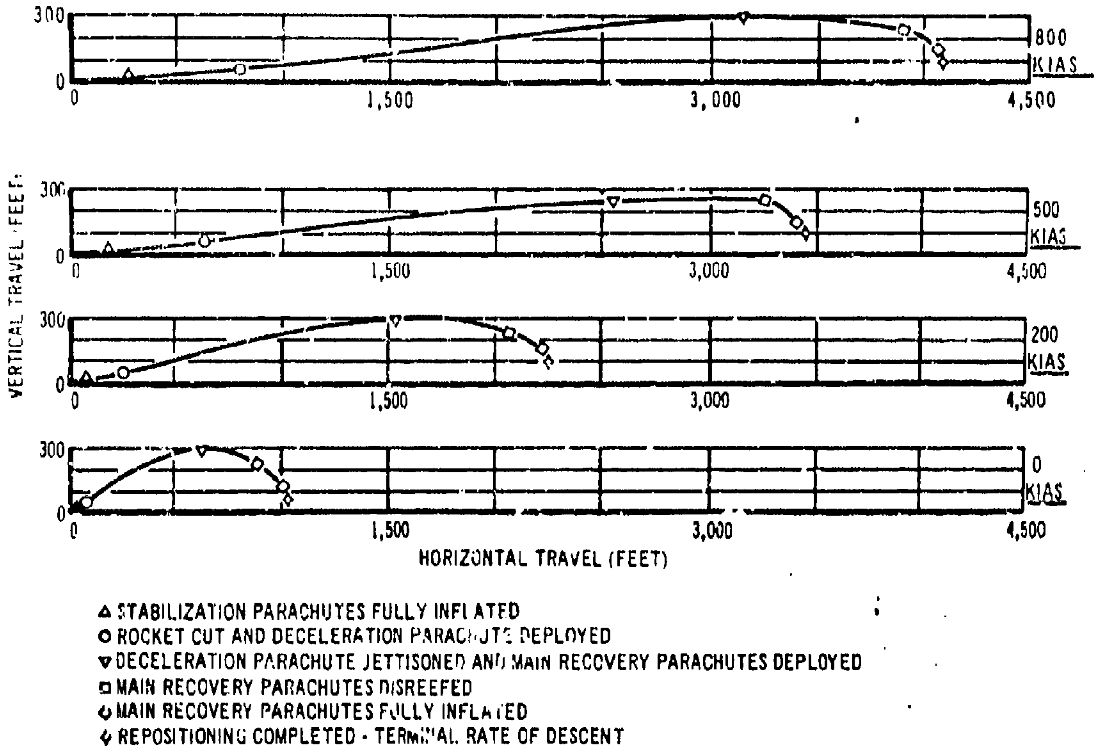


Figure 181. Boeing Supersonic Separable Nose Capsule – Trajectories with Respect to the Earth

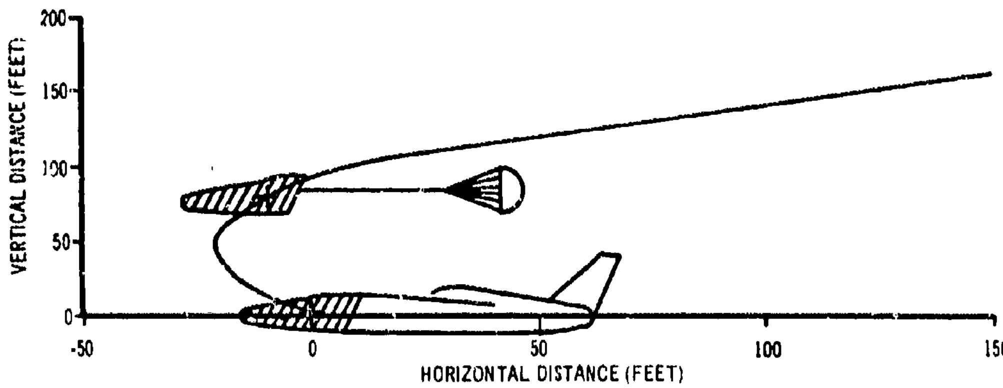


Figure 182. Boeing Supersonic Separable Nose Capsule – Trajectory with Respect to Airplane at 800 KIAS

5. MISCELLANEOUS ESCAPE DEVICES

a. STANLEY YANKEE ESCAPE SYSTEM

The Yankee escape system was conceived, designed, and tested by the Stanley Aviation Corporation. Three configurations can be provided to meet specific applications. The basic system, for escape above 200 feet altitude and at speeds to at least 350 knots, consists of a tractor extraction rocket and a standard personnel parachute. A zero-zero system for extending escape capability to zero speed and zero-altitude consists of the basic system plus a rocket extracted-ballistically operated parachute (REBOP) in lieu of the standard parachute, a drogue parachute for directional stability, and a folding seat whose back remains with the man. A high-speed system, for escape capabilities equal to those of ejection seats (450 knots), consists of the zero-zero system plus a powered inertia reel and a limb restraint garment.

When ejection is necessary, actuation of the ejection control jettisons the canopy and initiates launching of the spin-stabilized extraction rocket with integral launcher. Upon reaching riser line stretch, the extraction rocket is ignited and the crewman is ejected from the airplane to a height sufficient for safe recovery. The folding seat provides the knee and toe clearance required to remove the crewman in an erect posture through a small escape opening. An integral sensor separates the rocket from the crewman just prior to rocket burnout. A drogue parachute positions the crewman facing the relative wind for optimum recovery parachute deployment. A small tractor rocket extracts the REBOP parachute near apogee at low altitude, or by aneroid control during descent through 15,000 feet at high altitude. The drogue parachute is a pilot parachute for the REBOP if it is deployed manually. Following extraction, the parachute is forcibly spread ballistically. The ejection and recovery sequence is shown in Fig. 183.

6. ESCAPE AND SURVIVAL SUBSYSTEMS AND COMPONENTS

a. CAPSULE SEPARATION SYSTEMS

The successful development of the linear-shaped charge as the primary separation system for capsular escape vehicles is providing a method for solving the problem of increasing complexity of escape from supersonic aircraft. This concept offers a reliable, lightweight system for separating the inhabited section from the rest of the airplane by directive explosive cutting.

A survey of information and organizations regarding linear-shaped charges was conducted to obtain design data pertinent to linear-shaped charge separation systems in figure military aircraft, and to determine the advantages, penalties, and problems associated with the application of the linear-shaped charge (LSC) concept.

During the survey, published literature and industrial and governmental knowledge was collected and studied. It was found that important advances have been made in the field of high-temperature explosive materials.

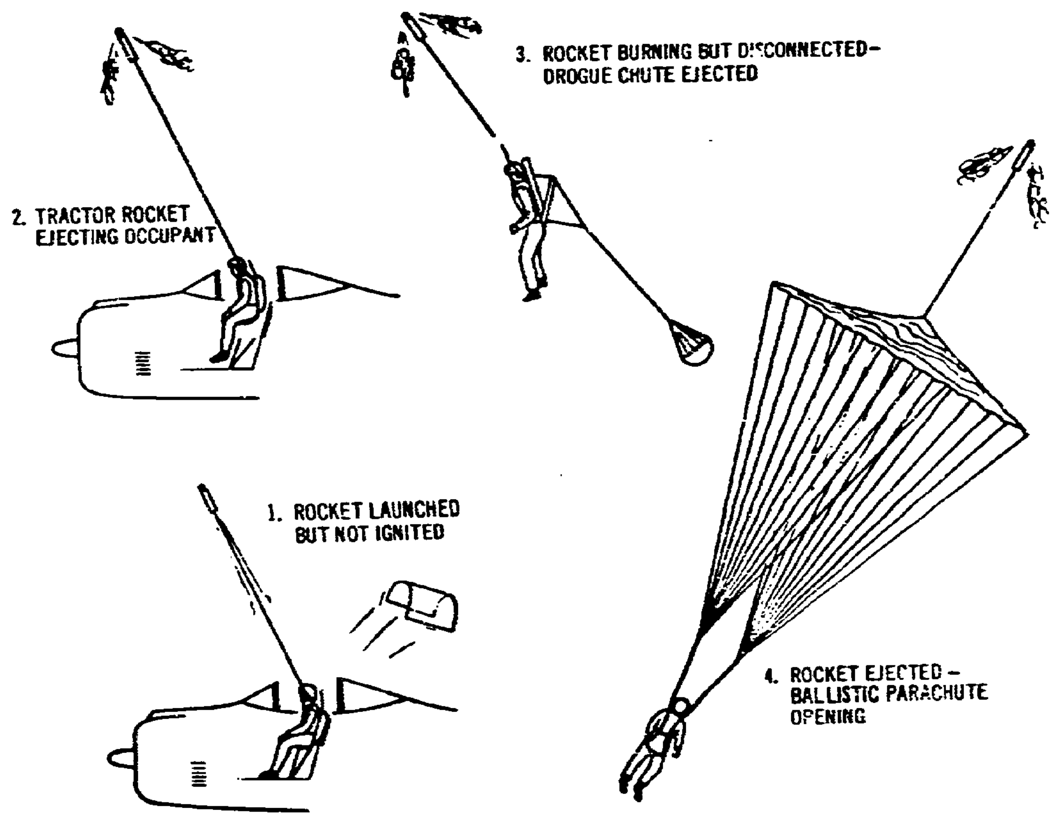


Figure 183. Stanley Yankee Escape System Ejection and Recovery Sequence

One example is the DuPont development of a high-temperature explosive, Tacot, which has a working temperature up to 610°F and a melting point of 710°F. The latest heat-resistant explosives used in linear-shaped charges are listed in Table XXXIII, with available information on maximum working temperatures and melting points. PETN and RDX are presently the most commonly used LSC explosive materials.

The most popular sheath materials for LSC are lead and aluminum shaped into a V-type configuration. Optimum standoff has been determined by vendor tests to be approximately two times the sheath groove depth. Core sizing is most reliably determined by actual testing of the part to be cut. However, at optimum standoff, core sizing can be estimated by the following formula: $W = Kt^2(He)^{0.6}$ where W = core weight gr./ft, t = thickness of material cut mils, H = Brinell hardness, e = density g/cc, and K = constant reflecting efficiency of charge design and materials against the particular target. During tests, the maximum thickness of 2024T-4 aluminum plate severed was 0.500 inch, using a 250 grain/foot RDX explosive linear-shaped charge. The same charge severed a 0.250 plate of 304 stainless steel. Thicker plates could be cut using larger charges. Linear-shaped charges must be initiated by an explosive shock. This shock is usually produced by initiators that are actuated by percussion techniques or electrical stimulus. The linear-shaped charge is detonated at a determined distance from the target and produces a sharply defined cutting action. (The shock wave is focused and reaches maximum velocity before striking the target.) Figure 184 shows a typical linear-shaped charge set up with respect to the target.

Results of the survey indicated that the use of linear-shaped charges for capsule separation from supersonic aircraft will provide a reliable, lightweight, precisely controlled system capable of instantaneous high-power cutting action. The development of Tacot high-temperature explosive strongly supports the feasibility of the shaped charge system in high-performance aircraft. Information was lacking for sizing the LSC for cutting such items as wire bundles, control cables, hydraulic tubes, and structural angle supports. Also, it was concluded that further investigation should be made of explosive material breakdown due to environmental conditions.

Table XXXIII. Capsule Separation Systems – Heat Resistant Explosives

Explosive	Maximum Working Temperature	Melting Temperature
PETN	160°F	285°F
RDX	280°F	400°F
HMX		545°F
DATB		
TACOT	610°F	710°F
EL 511		
DIPAM		
HNS		

b. LEDC ENERGY TRANSMISSION SYSTEMS

The low-energy detonating cord (LEDC) is a joint development of the Ensign Bickford Company and DuPont. It consists of a propellant train of PETN or RDX contained in a lead tube 0.040 inch in diameter. A PETN charge of one grain per foot provides reliable transmission and a detonation velocity of 24,000 feet per second.

Overbraided or sheathed LEDC and parts required for the adaptation of LEDC, as an improved energy transmission system for emergency crew escape systems, were developed by the Frankford Arsenal for the Air Force Flight Dyanamics Laboratory. The sheathed LEDC is used as a replacement for gas conduit lines for the initiation of various propellant actuated devices and linear-shaped charge capsule separation systems. LEDC systems have the advantages of reduced size and weight, higher operating speeds, and elimination of line boosters and restrictions on length of line between components. They are totally independent because they need no power supply, and are safe to handle because they require a specific means of initiation.

Figure 185 is a cross section of the overbraided, totally confined LEDC. It consists of a propellant train of 0.015-inch diameter PETN contained in a lead tube of 0.040 inch diameter. This lead tube is covered with rayon yarn, and held in place with a 0.170-inch diameter polyethylene sleeve which acts as a damping medium to the detonation. The fiberglass overbraiding is for added strength and is in a jacket of extruded polyethylene having an OD of 0.25 inch. In addition to resisting rupture, the cord has the advantages of being highly flexible, can be readily coiled in a 1-1/2 inch radius, is resistant to reasonable abrasion, and is light in weight (0.0267 pound per foot).

Figure 186 shows the XM58 mechanical initiator that is normally used to initiate an LEDC system by mechanical actuation from the cockpit or control point. A force of 25 to 30 pounds is required to withdraw the initiator pin which results in the firing of the unit. Figure 187 shows the XM59 gas initiator. This unit is used in applications where gas pressure is used to initiate LEDC systems. XM66, 67, 68, and 69 initiators (Fig. 188) are units that are actuated by LEDC, and contain small cartridges that produce gas pressure to actuate the firing pin of any propellant actuation device (PAD). These units are provided as straight fittings, similar to a standard union or couple, or as 90-degree elbow fittings. They are available with either MS or pipe threaded ports, thereby making them compatible with existing PAD.

Various types of fittings are available for interconnecting LEDC systems. Figure 189 shows a cross fitting and Fig. 190 shows a T-fitting, 90-degree bulkhead, and union bulkhead fittings.

Figure 191 shows a check valve that allows a detonation wave, traveling in one direction in a LEDC line, to pass through the valve and continue through the system. However, a detonation wave traveling in the opposite direction will be stopped by the valve.

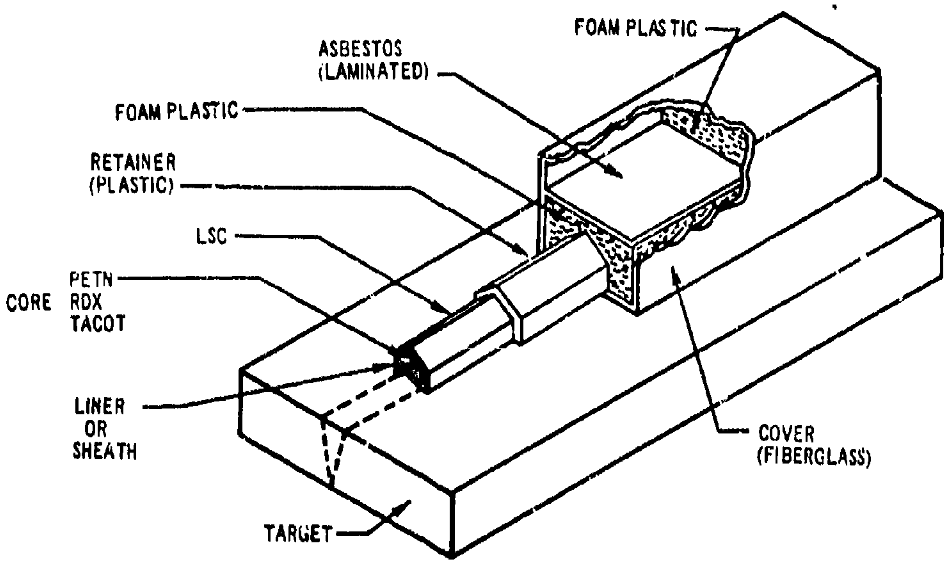


Figure 184. Capsule Separation Systems – Typical Linear Shaped Charge Setup

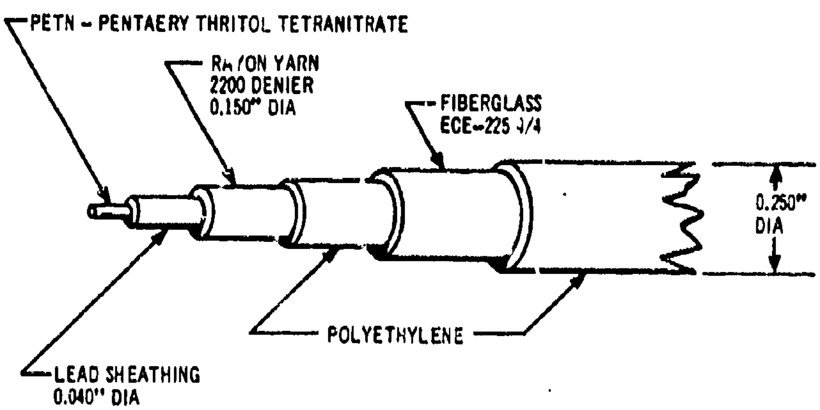


Figure 185. Cross Section, Low Energy Detonating Cord

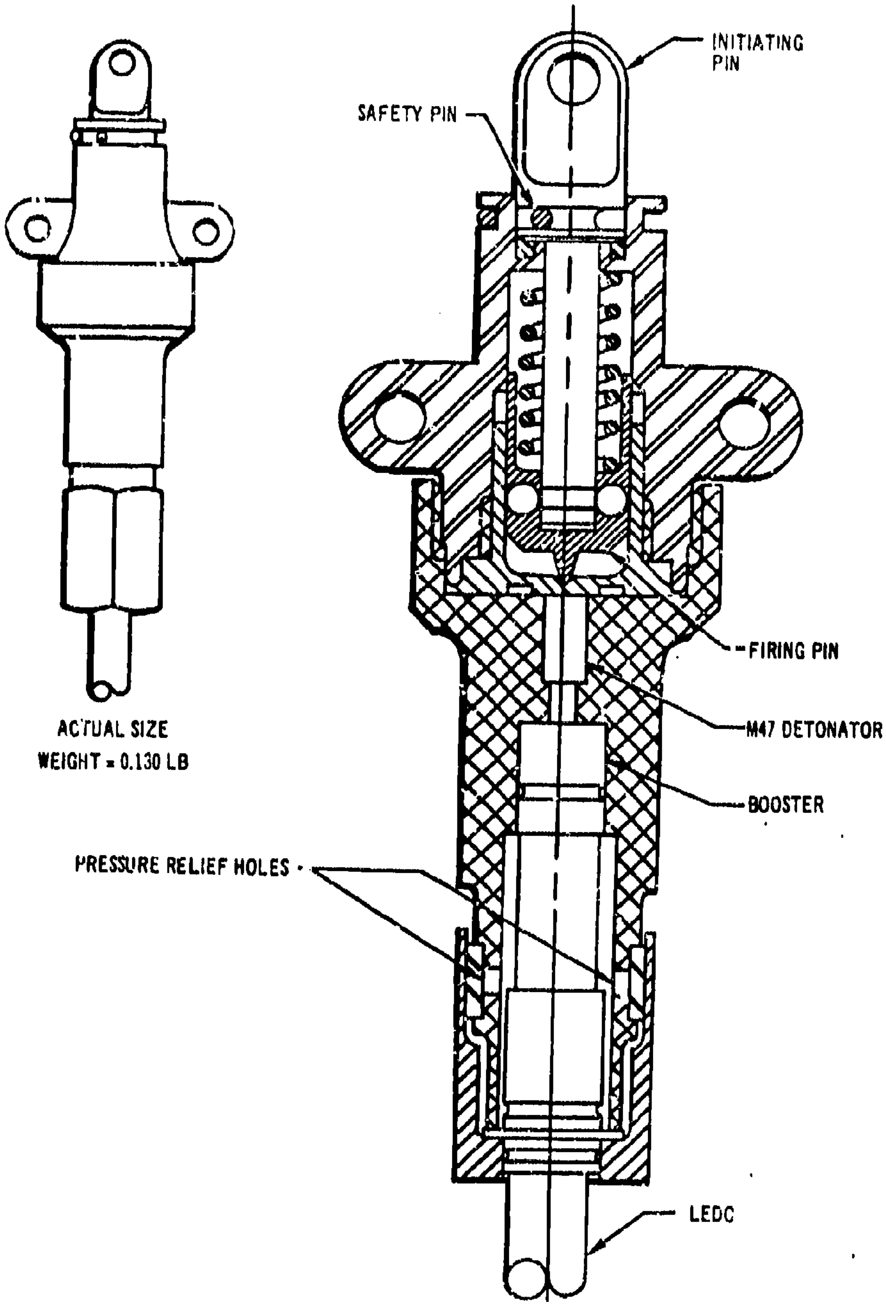


Figure 186. XM58 Mechanical Initiator

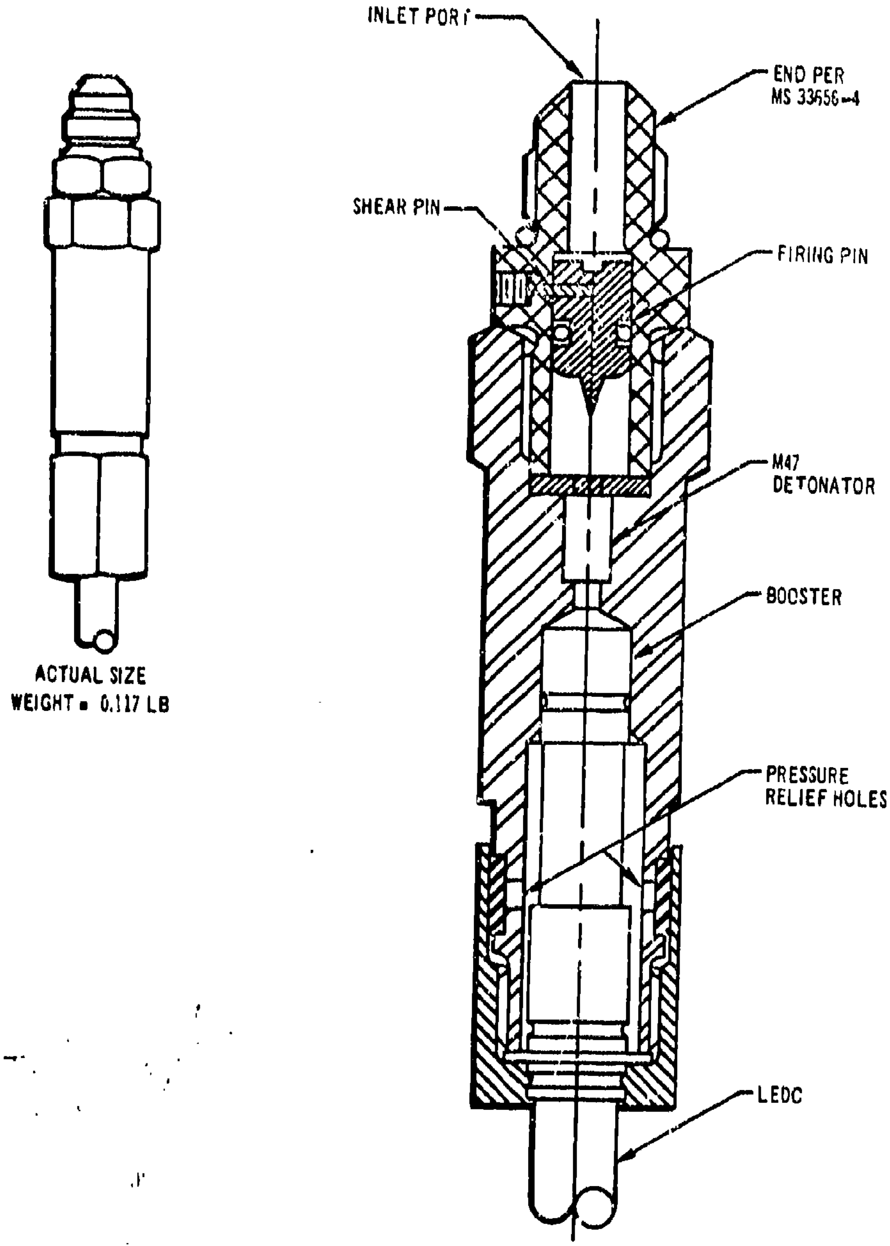
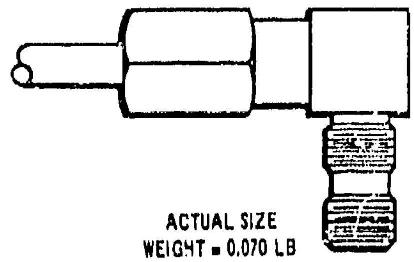
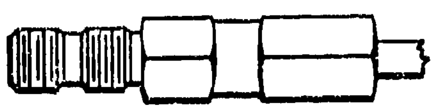
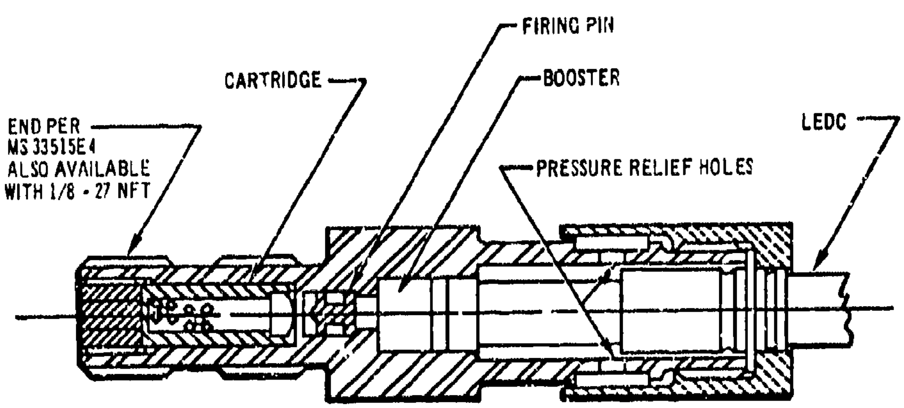


Figure 187. XM59 Gas Initiator



XM68 AND XM69 INITIATORS





XM66 AND XM67 INITIATORS

Figure 188. Frankford Arsenal LEDC Initiators

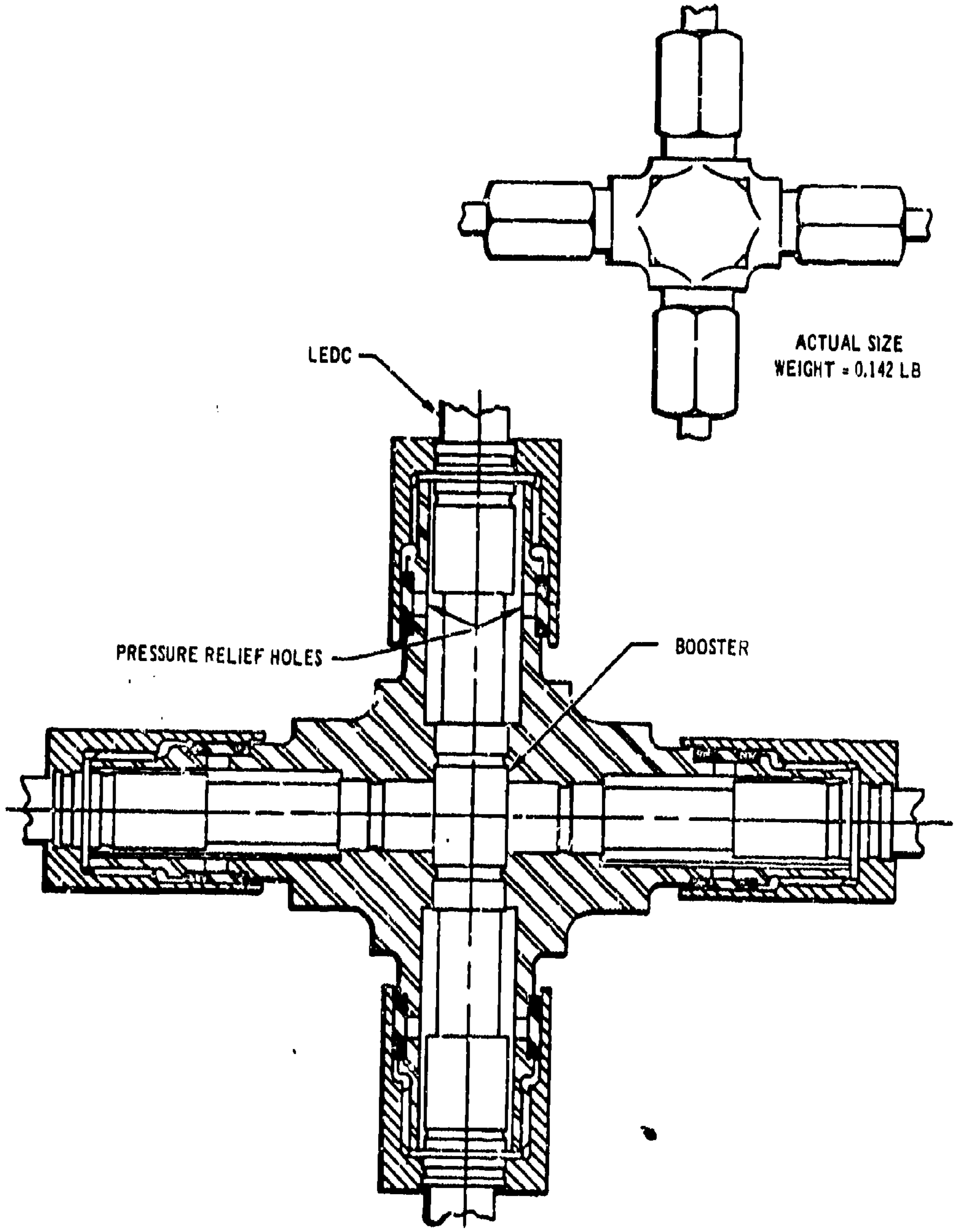


Figure 189. Cross Fitting

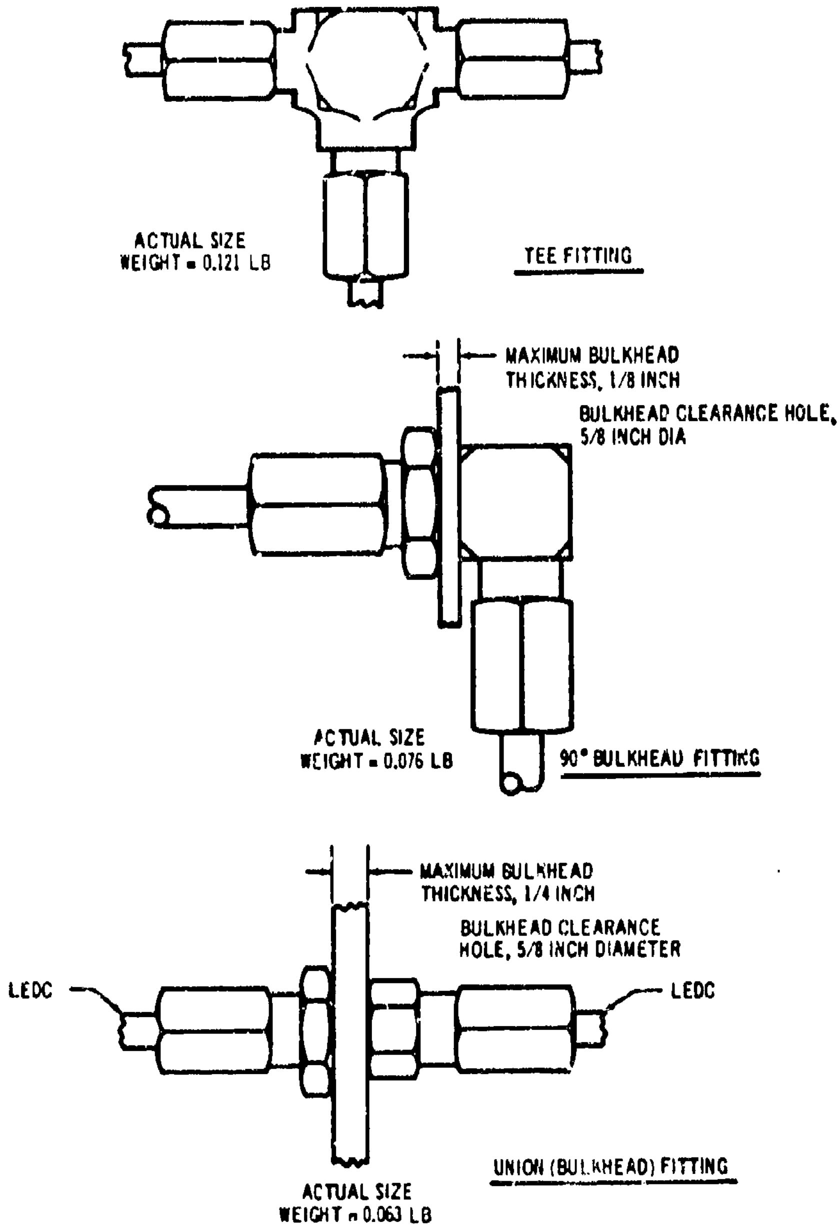


Figure 190. Frankford Arsenal LEDC Fitting

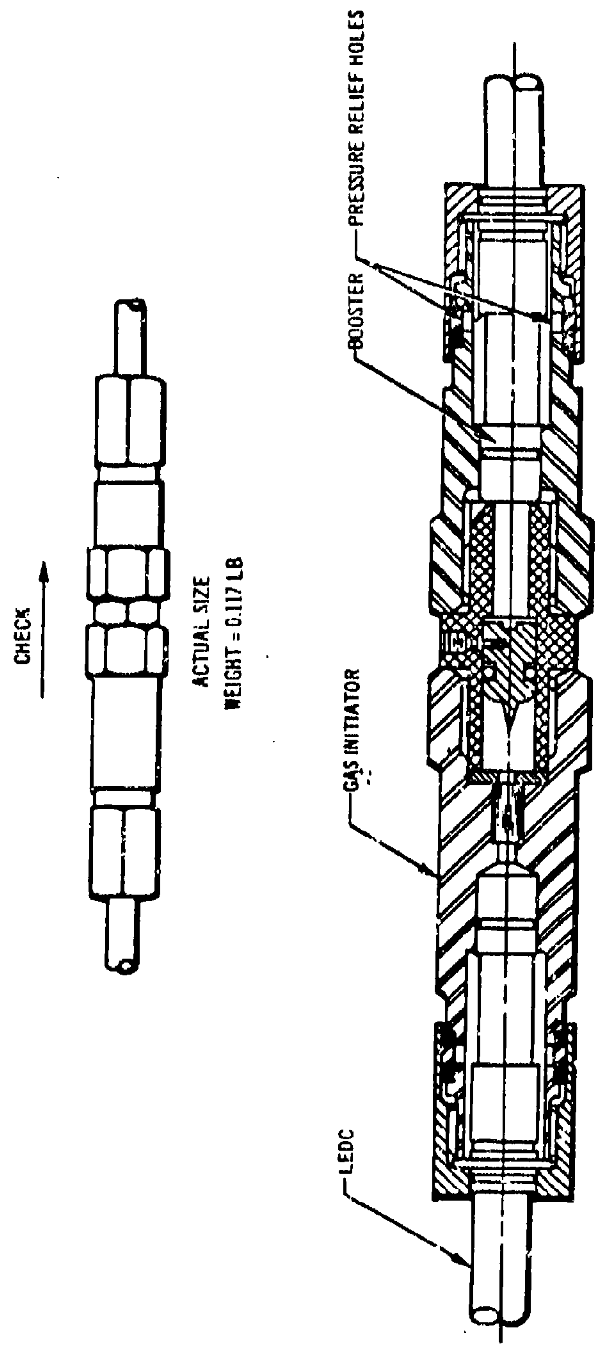


Figure 191. LEDC Check Valve

c. PROPELLANT-ACTUATED DEVICES

Actuator, Center Beam Release, Canopy,
Talley Industries, P/N 30189

Used on the F-111 to release the canopy from the airplane. It pulls against a 1000 pound load for 0.3 inch, and then strokes out to 0.8 inch while the load reduces to almost zero. The unit size is 2.15 inches by 4.37 inches by 4.67 inches extended, or 3.88 inches retracted. See Fig. 192. Unit weight is 0.3 pound.

Actuator, Seat Adjustment,
Talley Industries, P/N 30147-3

Used in conjunction with Talley rocket-catapult, P/N 10,100-1, to raise and lower the rocket-catapult with seat on the F-105, airplane.

This electromechanical unit maintains proper relationship between rocket motor thrust line and CG of man and seat to prevent tumbling. Rated operating load is 500 pounds. Maximum operating load is 700 pounds. Electrical stroke is 4.26 inches nominal. The stroke velocity at rated load is 1.4 to 3.0 feet/minute. The unit size is approximately 5 by 5 by 12.58 inches extended, or 8.12 inches retracted. See Fig. 193. Unit weight is 7 pounds maximum.

Actuator, "B" Seat Foot Pan,
Rocket Power, Inc., P/N 1964-11

Ballistically retracts the foot cables and positions the feet and legs for safe ejection in the "B" seat. Unit has two spring-operated cables (one at each end of unit) which attach to the crewman's heels with slight tension maintained for normal flight operations. Unit contains a dual function rotary actuator. The unit size is 4.75 inches diameter by 17.70 inches. See Fig. 194.

Actuator, Rotary (Man-Seat Separator),
Talley Industries, P/N 1000

The unit is applicable to the B-47, B-52, B-58, B-66, F-100, F-101, F-102, F-104, F-105, T-33, T-37, T-38, and CL-141

In operation, upon lap belt opening, the lap belt initiator fires the rotary actuator cartridge to retract the actuator webbing an average of 15 inches. The webbing, which extends down between the seat and man's back pack, under survival kit, to attachment on the front lip of the seat, is then pulled taut to separate the crewman from the seat.

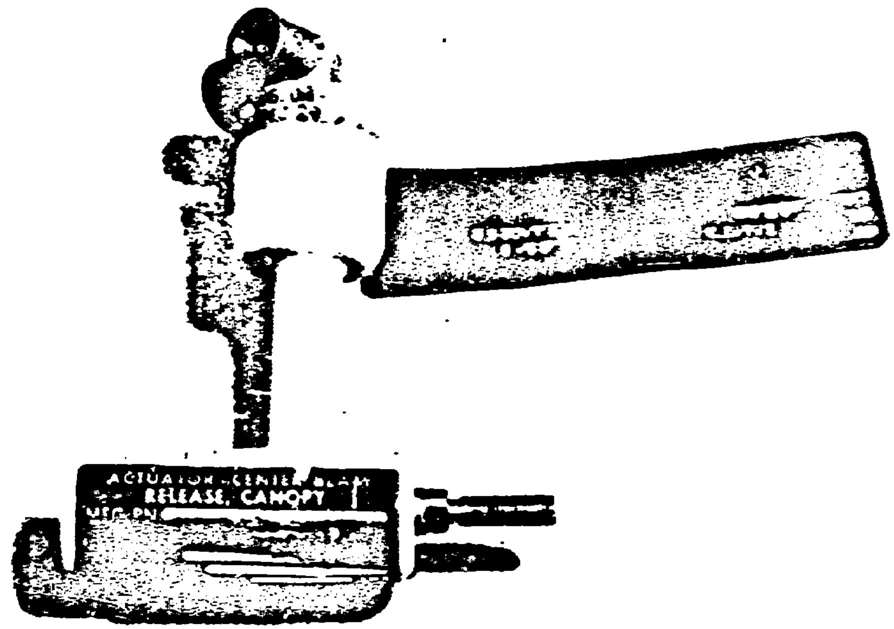


Figure 192. Actuator, Center Beam Release, Canopy – Talley Industries P/N 30189

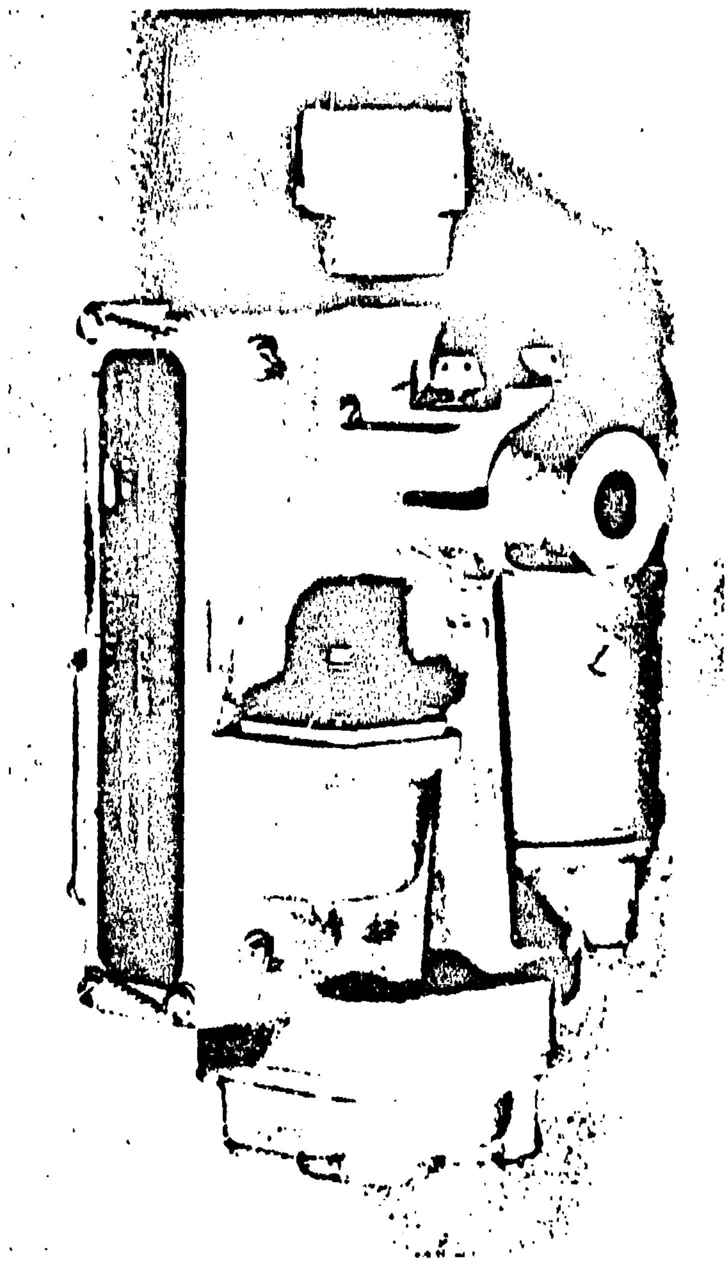


Figure 193. Actuator, Seat Adjustment – Talley Industries P/N 30147

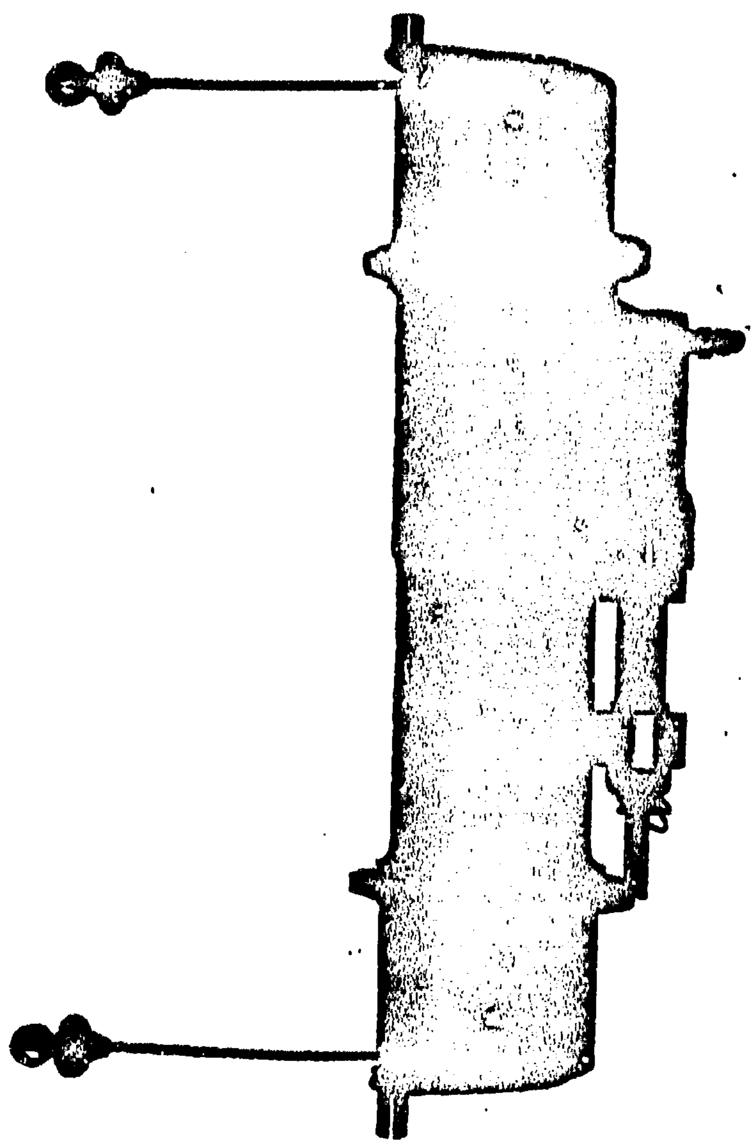
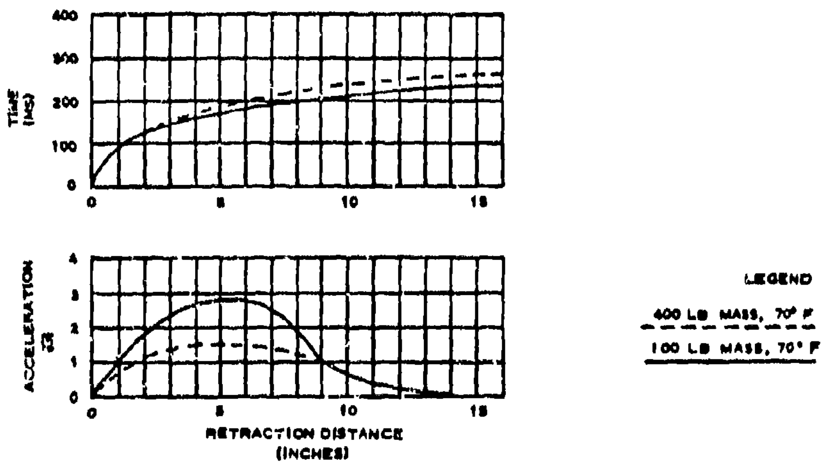


Figure 194. Actuator, "B" Seat Foot Pan – Rocket Power, Inc. P/N 1964-11

The unit is capable of separating a mass varying in weight from 100 to 400 pounds, from an immovable seat in 0.50 second maximum. Rate of onset, acceleration, etc. are shown in the plots below.



The unit's size is 2.26 inches diameter by 3.134 inches long. See Fig. 195. Unit weight is 3.5 pounds maximum.

Ballistic Rotary Actuator (Man-Seat Separator), Rocket Power, Inc., P/N 1925

The unit is used on T-33, F-84, F-100, F-101, F-102, F-104, and F-105. It separates man from seat during the emergency ejection sequence. Retraction length is 15 inches. Retraction force is 1700 pounds. Retraction acceleration is 7g maximum against a 100-pound load. Retraction time is 0.45 second maximum. Its size is 2.25 inches by 8.25 inches. See Fig. 196. Unit weight is 2.5 pounds (approximately).

Breakaway Bolts (Propellant-Powered), Rocket Power, Inc., P/N's 1546 and 1548

Four of these bolts attach the Convair "B" seat to the cradle frame. When initiated at instant of seat-man launch, the bolts break away simultaneously to release seat from airplane.

The small charge of propellant in the bolt cavity, when ignited, develops internal pressure sufficient to cause the bolt body to fail at the breakaway section without fragmentation.

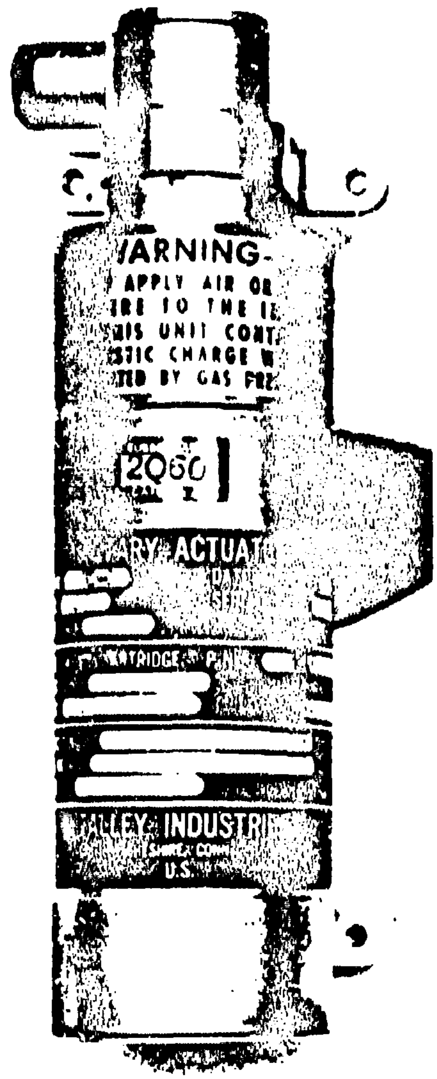


Figure 195. Actuator, Rotary (Man-Seat Separator) – Talley Industries P/N 1000

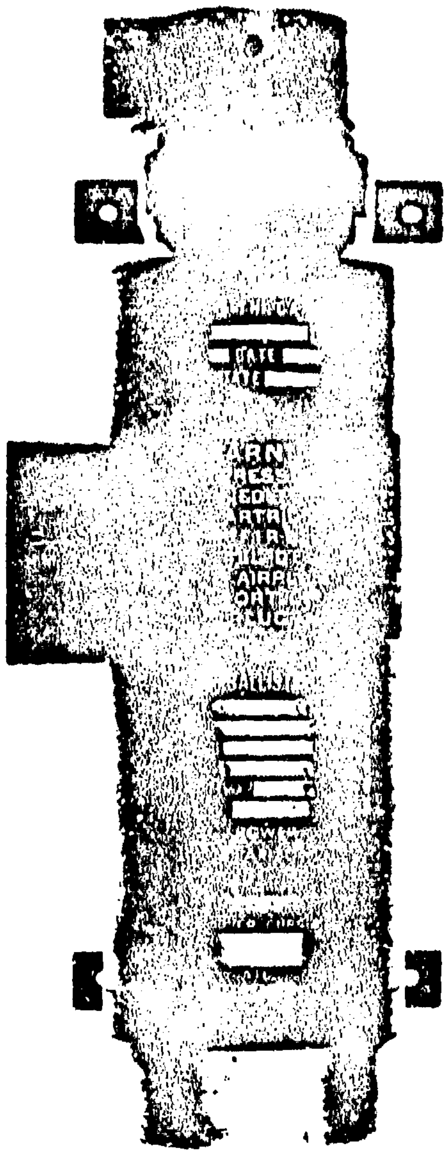


Figure 196. Ballistic Rotary Actuator (Man-Seat Separator) – Rocket Power, Inc. P/N 1925

Ultimate tension is 22,000 pounds. Tension failure is at 25,000 pounds. Separation time after initiation is 0.002 second. Unit 1546-13 is 1.4 by 2.75 by 3.35 inches and weighs 1 pound. See Fig. 197. Unit 1548-13 is 1.48 by 2.75 by 4.54 inches and weighs 1.4 pounds. See Fig. 198.

Ballistic-Inertia Harness Reel,
Rocket Power, Inc., P/N 1293

This unit is used on the A-5 (A3J). It combines the normal inertial reel functions and emergency ejection positioning of the seat occupant. Performance data are as follows:

- Strap extension, 18 inches.
- Retraction time, 0.3 second nominal.
- Retraction velocity, 12 fps maximum.
- Rate of acceleration change, 250 g/second.
- Stall force, 800 pounds.

Unit is shown in Fig. 199. Weight is 5.75 pounds (total system weight is 7.6 pounds).

Gas Generator,
Talley Industries, P/N 1450-14

The gas generator is used on the B-58 encapsulated seat to actuate the torso-retracting inertia reel and the leg-positioning mechanism, and to pressurize the door-closing thruster. The unit has a 20 cubic inch capacity with an output of 1000 psi in 0.5 second. Its size is 2.00 by 6.22 by 14.20 inches. Unit weight is 2.75 pounds (see Fig. 200).

Gas Generator,
Frankford Arsenal XM14

The XM14 gas generator was developed by Frankford Arsenal for the same use as the Talley Industries P/N 1450-14 gas generator. The unit provides a source of pneumatic power for operating preejection leg positioning, torso positioning, and capsule door closure for the B-58 encapsulated ejection seat. A dual power source is provided that permits enclosure of the crew member in an emergency. If the emergency passes and the capsule doors are reopened, the second charge may be fired to operate the system if necessary. A high temperature resistant propellant and igniter are used to meet extended storage life and operating requirements at 200°F. Figure 201 shows the pressure versus time operating characteristics for a test firing into a 21 cubic inch volume test fixture.

Gas Generator,
Talley Industries, P/N 2600-17

The gas generator is used in the recovery system of the B-58 encapsulated seat. It contains an aneroid that permits capsule free fall to 15,000 feet. When 15,000 feet is reached, the gas generator is activated and the parachute is deployed. The gas generator is activated immediately if ejection

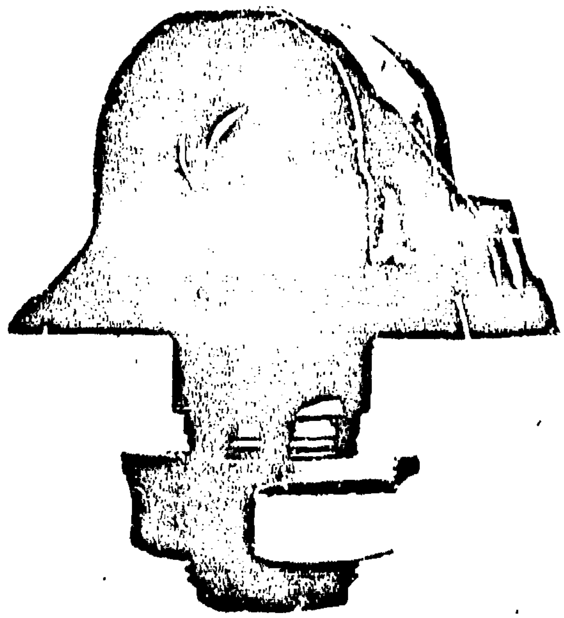


Figure 197. Breakaway Bolt – Rocket Power, Inc. P/N 1546

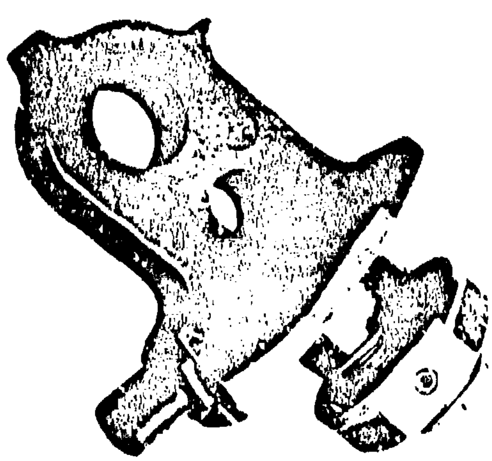


Figure 198. Breakaway Bolt – Rocket Power, Inc. P/N 1548

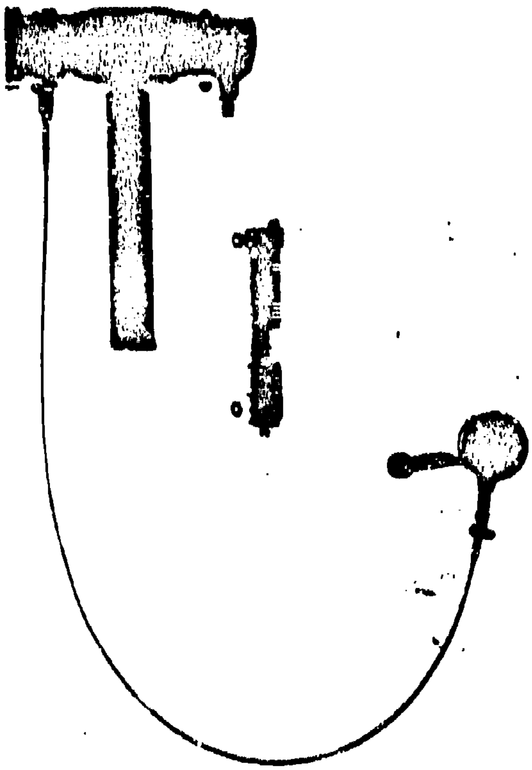


Figure 199. Ballistic Inertia Harness Reel – Rocket Power, Inc. P/N 1293

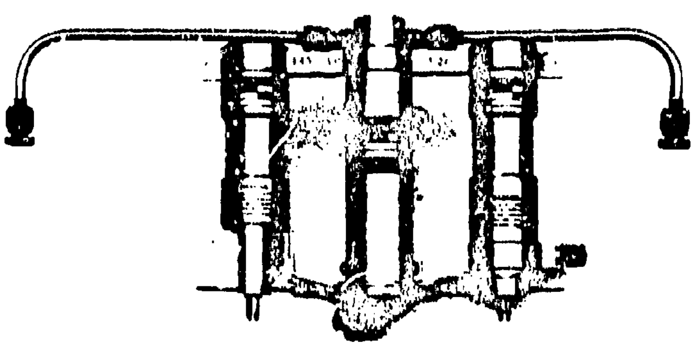


Figure 200. Gas Generator – Talley Industries P/N 1450-14

is below 15,000 feet. The unit size is 2.515 inches maximum by 4.26 inches maximum by 5.082 inches maximum. See Fig. 202. Unit weight is 4.75 pounds.

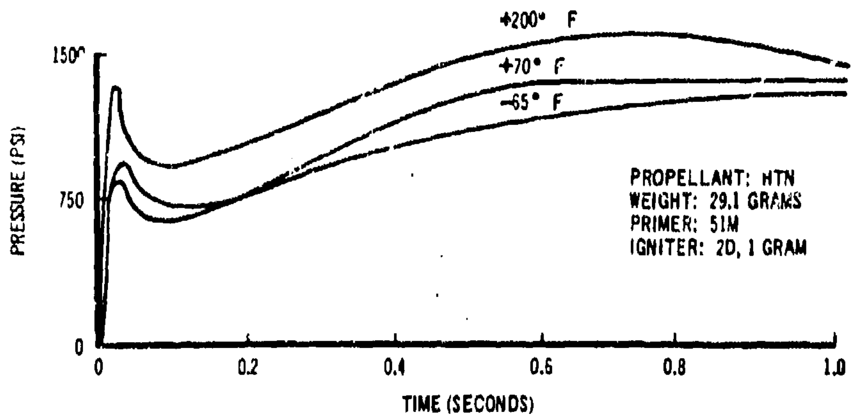


Figure 201. XM14 Gas Generator Pressure-Time for 21 Cu In. Vol

Barostat Lock Initiator,
Talley Industries, P/N 90166

This is an aneroid-controlled unit used on the F-111 to actuate at 15,000 feet or below. If ejection is accomplished at an altitude over 15,000 feet, the initiator will not actuate. When the pilot descends to 15,000 feet, the initiator actuates and initiates SMDC (Shielded Mild Detonating Cord). The SMDC accomplishes a number of ejection functions, one of which is deploying the chute. The unit size is 2.22 by 3.54 by 4.75 inches. See Fig. 203. Unit weight is 1.55 pounds.

Rocket Catapult,
Rocket Power, Inc., P/N 1720-10

The unit is used on the North American B-70 to launch emergency escape capsule from aircraft. Thrust data is as follows:

- Catapult and cartridge, 12,400 pounds.
- Impulse, 3100 pound-seconds.
- Time, 0.30 second.

Acceleration data is 16g, 160g/second. The unit is 4 inches by 5 feet, 5 inches (approximately). See Fig. 204. Unit weight is 50 pounds (approximately).

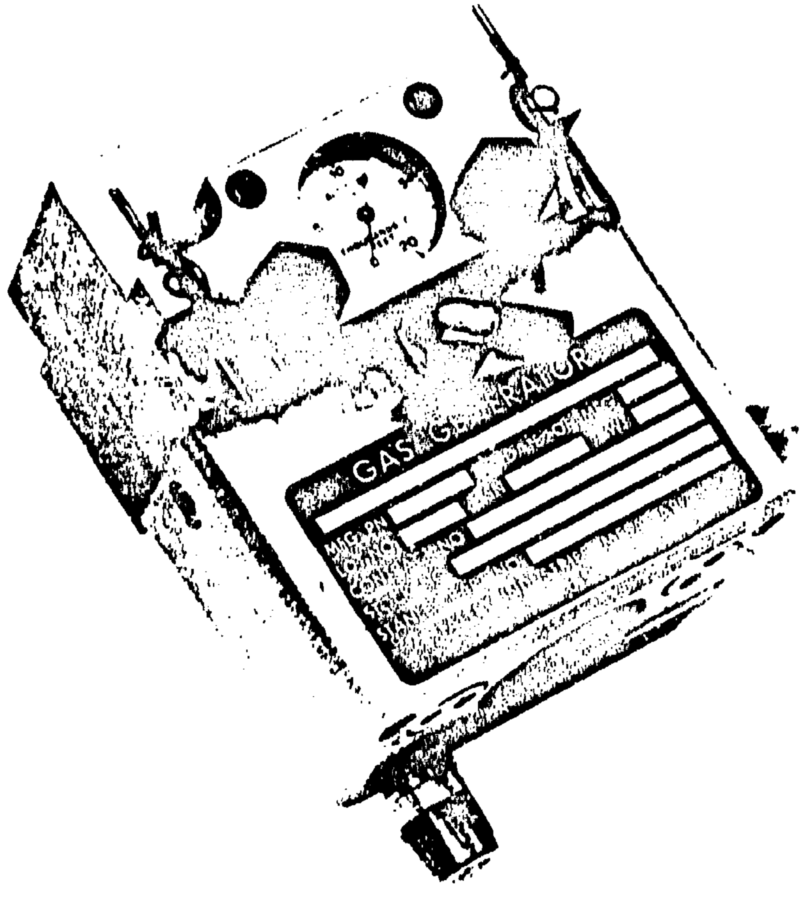


Figure 202. Gas Generator – Talley Industries P/N 2600-17

Figure 203. Barostat Lock Initiator – Talley Industries P/N 90166

Figure 204. Rocket Catapult – Rocket Power, Inc. P/N 1720-10

Rocket Catapult,
Talley Industries, P/N 10,100

The unit is applicable to the F-102, F-104, F-105, and X-15. It is physically interchangeable with the XM10, but is designed to give the crewman sufficient altitude to allow a zero-zero ejection.

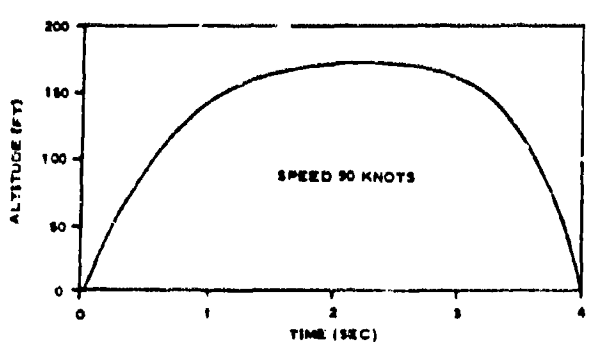
Total impulse of rocket and catapult is 2700 pound-seconds. Burn time of motor is 0.5 second. Maximum acceleration is 15g. Maximum rate of onset is 160g/second. Altitudes as high as 480 feet have been reached with a 400 pound ejected mass. The unit is 3.25 inches diameter by 45.00 inches. See Fig. 205. Unit weight is 32 pounds (approximately).

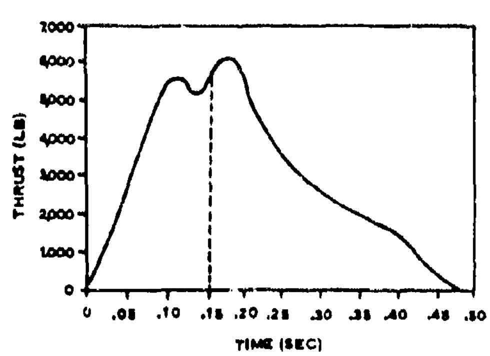
Rocket Catapult,
Talley Industries, P/N 2400

The unit is used on the F-86, F-100, T-33, and CL-141. Performance data are as follows:

- Catapult thrust, 4,700 pounds (-65°F), 5,250 pounds (+70°F), 6,000 pounds (+200°F).
- Rocket thrust, 5,500 pounds (-65°F), 6,000 pounds (+70°F), 6,400 pounds (+200°F).
- Rocket burn time (average), 0.25 second.
- Acceleration, 14.6g (-65°F), 16.0g (+70°F), 18.0g (+200°F).
- Rate of acceleration, 150g/second (-65°F), 170g/second (+70°F), 200 g/second (+200°F).
- Velocity at separation (average), 50 feet/second.
- Total impulse (average), 1,550 pound/seconds.

Performance figures are based on a specific seat using a 45-degree rocket nozzle angle and with a 375 pound seat-man mass. Unit size is 2.5 by 4 by 39 inches. See Fig. 206. Unit weight is 20 pounds.





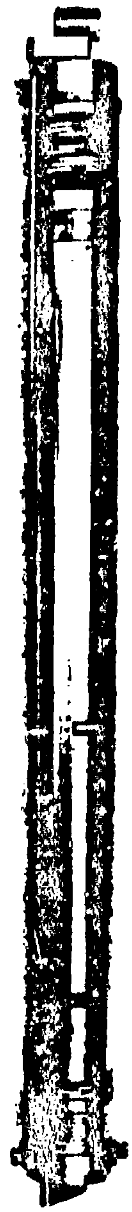


Figure 205. Rocket Catapult – Talley Industries P/N 10,100

Rocket-Catapult,
Talley Industries, P/N 10006

The unit is applicable to the A5(A3J), T2(T2J), 0V10A, and LW2 seat. Performance characteristics are the same as for Talley P/N 2400, but the catapult, instead of being carried piggy-back, is now in line with the rocket motor. Unit size is 3 inches diameter by 43.5 inches. See Fig. 207. Unit weight varies from 21.25 pounds to 23.5 pounds.

Rocket Catapult,
Rocket Power, Inc., P/N 1057

The unit is government standard LAU 28/A and is applicable to the F-102 and F-106. Performance data are as follows:

- Impulse, catapult — 500 pound seconds, rocket — 1,100 pound seconds.
- Maximum thrust, catapult — 6,000 pounds, rocket motor — 3,600 pounds.
- Maximum acceleration, 15.2g.
- Maximum onset rate, 122g/second.
- Burning time, catapult — 0.169 second, rocket motor — 0.274 second.

The unit size is 3.5 by 50 inches, and it weighs 35 pounds.

Rocket-Catapult,
Rocket Power, Inc., P/N 1192

The unit is a replacement for NAMC, Type II, and used on the T-2 (T2J). Performance data are as follows:

- Impulse, catapult — 500 pound seconds, rocket — 900 pound seconds.
- Maximum thrust, catapult — 5,500 pounds, rocket motor — 4,700 pounds.
- Maximum acceleration, 15.5g.
- Maximum onset rate, 151g/second.
- Burning time, catapult — 0.147 second, rocket motor — 0.212 second.

Unit size is 4 by 43 inches, and it weighs 30 pounds.

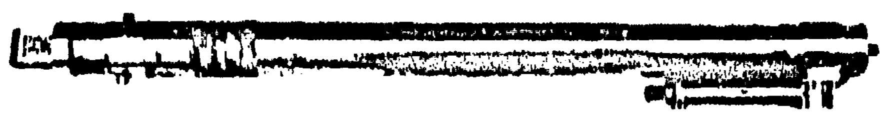


Figure 206. Rocket Catapult – Talley Industries P/N 2400

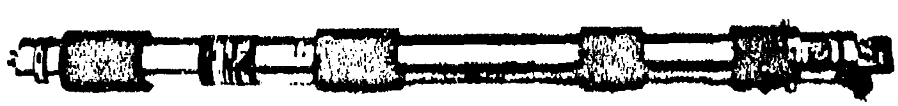


Figure 207. Rocket Catapult – Talley Industries P/N 10,006

Rocket Catapult,
Rocket Power, Inc., P/N 1289

The unit is a replacement for NAMC, Type II, and is used on the A-5 (A3J). Performance data are as follows:

- Impulse, catapult — 500 pound seconds, rocket — 900 pound seconds.
- Maximum thrust, catapult — 5,000 pounds, rocket motor — 4,400 pounds.
- Maximum acceleration, 14.2g.
- Maximum onset rate, 163g/second.
- Burning time, catapult — 0.165 second, rocket motor — 0.201 second.

Unit size is 4 by 43 inches. See Fig. 208. Unit weight is 30 pounds.

Rocket-Catapult,
Rocket Power, Inc., P/N 1407

The unit is applicable to the X-15. Performance data are as follows:

- Impulse, catapult — 700 pound seconds, rocket — 1,050 pound seconds.
- Maximum thrust, catapult — 7,500 pounds, rocket motor — 4,400 pounds.
- Maximum acceleration, 16.0g.
- Maximum onset rate, 188g/second.
- Burning time, catapult — 0.140 second, rocket motor — 0.243 second.

Unit size is 3.5 by 50.312 inches. See Fig. 209. Unit weight is 36 pounds.

Rocket-Catapult,
Rocket Power, Inc., P/N 2124

The unit is a replacement for the M5 catapult and is applicable to the F-84, M-2, X22A, CT114, OV10A, MOD Pack II, and LL simulator. Performance data are as follows:

- Impulse, catapult — 555 pound seconds, rocket — 1,210 pound seconds.
- Maximum thrust, catapult — 4,700 pounds, rocket motor — 4,600 pounds.
- Maximum acceleration, 16.0g.
- Maximum onset rate, 160g/second.
- Burning time, catapult — 0.155 second, rocket motor — 0.272 second.

Unit size is 2.44 by 41.50 inches. See Fig. 210. Unit weight is 18.5 pounds.

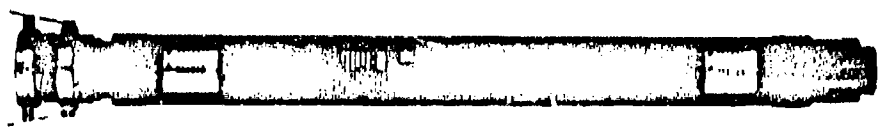


Figure 208. Rocket Catapult – Rocket Power, Inc. P/N 1289

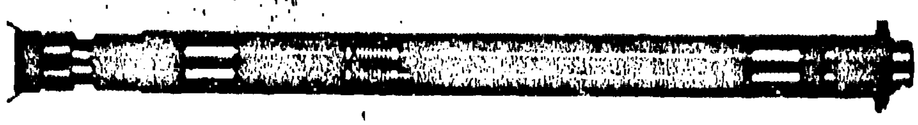


Figure 209. Rocket Catapult – Rocket Power, Inc. P/N 1407

Rocket-Catapult,
Rocket Power, Inc., P/N 2174

The unit is a replacement for the M10, M8, M9, Repac I, and M3 catapult and is applicable to the F-106, F-104, A7A, SC-142, TA 4E, CL-84, XV4A, and COIN (G.C. Charger). Performance data are as follows:

- Impulse, catapult — 600 pound seconds, rocket — 2,000 pound seconds.
- Maximum thrust, catapult — 5,800 pounds, rocket motor — 4,500 pounds.
- Maximum acceleration, 14.3g.
- Maximum onset rate, 177g/second.
- Burning time, catapult — 0.155 second, rocket motor — 0.465 second.

Unit size is 3.5 by 44 inches. See Fig. 211. Unit weight is 28 pounds.

Rocket-Catapult,
Rocket Power, Inc., P/N 2184

The unit is a replacement for the M5 catapult and is applicable to the F-100 and T-33. Performance data are as follows:

- Impulse, catapult — 545 pound seconds, rocket — 1,250 pound seconds.
- Maximum thrust, catapult — 4,500 pounds, rocket motor — 4,600 pounds.
- Maximum acceleration, 17g.
- Maximum onset rate, 170g/second.
- Burning time, catapult — 0.151 second, rocket motor — 0.302 second.

Unit size is 2.56 by 39 inches. See Fig. 212. Unit weight is 23 pounds.

Rocket-Catapult,
Rocket Power, Inc., P/N 2194

The unit is used on the Gemini. Performance data is as follows:

- Impulse, catapult — 700 pound seconds, rocket — 1,900 pound seconds.
- Maximum thrust, catapult — 7,500 pounds, rocket motor — 8,200 pounds.
- Maximum acceleration, 19.7g.
- Maximum onset rate, 318g/second.
- Burning time, catapult — 0.134 second, rocket motor — 0.273 second.

Unit size is 3.92 by 46 inches. See Fig. 213. Unit weight is 28.5 pounds.

Figure 210. Rocket Catapult – Rocket Power, Inc. P/N 21[illegible]4

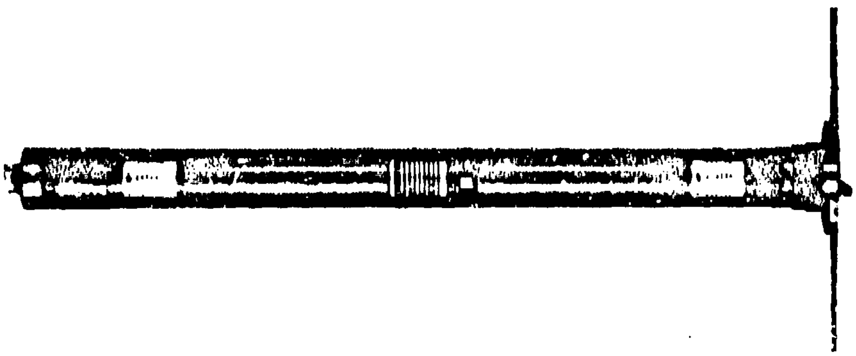


Figure 211. Rocket Catapult – Rocket Power, Inc. P/N 2174

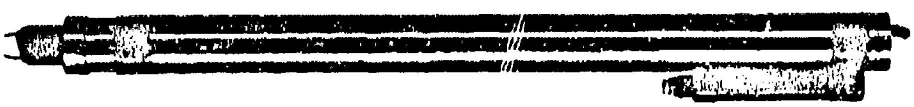


Figure 212. Rocket Catapult – Rocket Power, Inc. P/N 2184

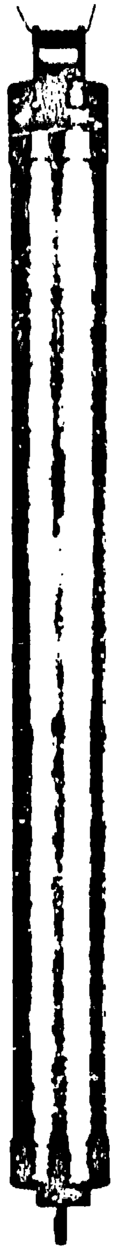


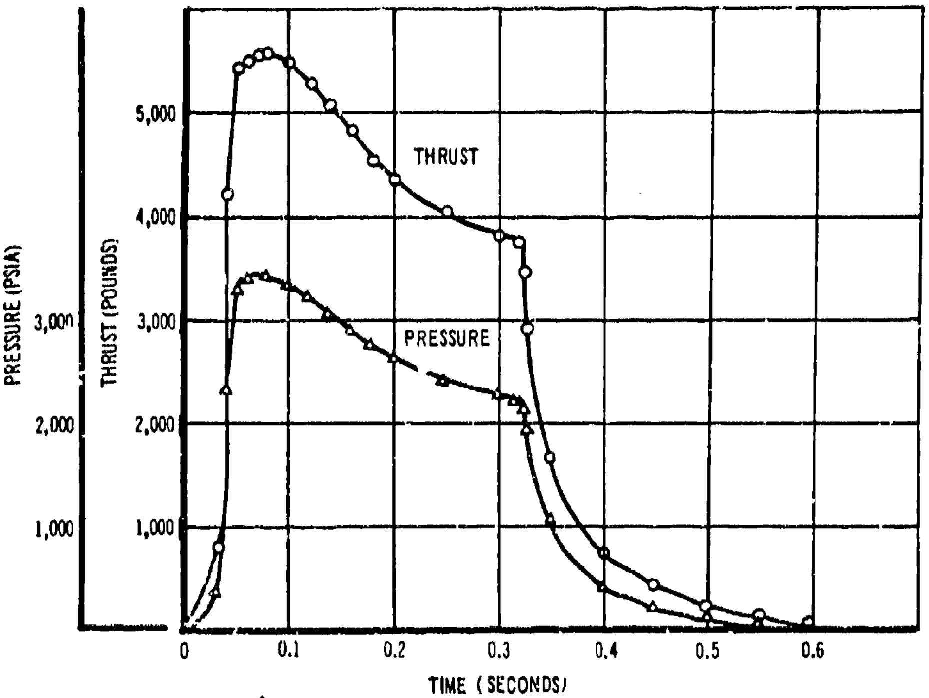
Figure 213. Rocket Catapult – Rocket Power, Inc. P/N 2194

Rocket-Catapult,
Thiokol Chemical Corporation

Principal characteristics and nominal ballistic performance at 60°F.

ENGINE DESIGNATION	TE-M-83	TE-M-139	TE-M-239	TE-M-244	TE-M-295	TE-M-303	TE-M-308	TE-M-324 (A27I-100N)
APPLICABLE AIRCRAFT	F-102	F-106	121 & A3J	P6M & B-58 RETROFIT	X-15	B-58	B-70	B-58 CAPSULE
STATUS	OPER	OPER	OPER	OPER	OPER	DEV	DEV	OPER
LENGTH (INCHES)	42.0	15.0	36.5	42.0	42.0	36.5	58.0	36.0
DIAMETER (INCHES)	2.50	4.06	2.50	2.50	2.50	3.00	3.19	3.05
NOZZLE CANT ANGLE	49° 48'	54° 30'	63° 45'	43° 31'	-	49° 55'	28° 25'	60° & 67°
TOTAL WEIGHT (LB)	20.0	21.0	17.0	20.0	20.0	21.0	33.0	16.5
PROPELLANT WEIGHT (LB)	6.3	5.3	5.0	6.3	6.3	9.3	16.0	8.0
PROPELLANT TYPE	POLYSULFIDE	POLYSULFIDE	POLYSULFIDE	POLYSULFIDE	POLYSULFIDE	POLYSULFIDE	POLYSULFIDE	POLYSULFIDE
TEMPERATURE RANGE	-40°F to +160°F	-65°F to +160°F	-65°F to +160°F	-65°F to +160°F	-60°F to +160°F	-65°F to +200°F	-65°F to +200°F	-65°F to +200°F
MAXIMUM THRUST (LB)	4,600	3,250	4,800	4,600	9,500	4,000	10,000	5,500
AVERAGE THRUST (LB)	3,200	1,500	3,600	3,000	6,000	2,600	6,800	3,950
DURATION (SEC)	0.300	0.720	0.200	0.300	0.15	0.650	0.280	0.300
TOTAL IMPULSE LB-SEC	1,100	1,100	875	1,100	880	1,260	3,050	1,475
MAXIMUM PRESSURE (PSIA)	4,000	3,000	4,000	4,000	-	3,000	3,800	3,000
AVERAGE PRESSURE (PSIA)	2,400	1,450	2,900	2,250	-	1,500	2,300	2,300

The following graph shows the pressure and thust versus time characteristics for the TE-M-324 engine.

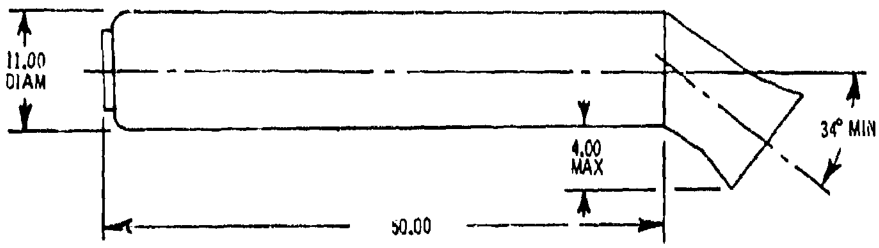


Boost Rocket,
Talley Industries, P/N 50136

The Rocket was proposed for the Boeing ADO-12 airplane design separable nose capsule. Performance characteristics at +59°F are as follows:

- Average thrust, 68,000 pounds.
- Burn time, 0.6 second.
- Total impulse, 40,800 pound/seconds.

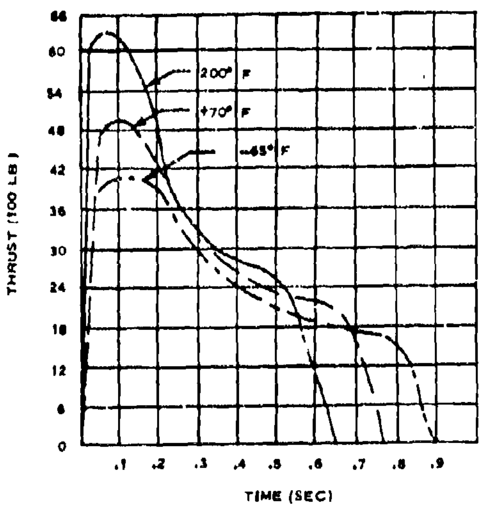
Dimensions are shown below. Total unit weight is 264 pounds.



Escape Rocket,
Rocket Power, Inc., P/N 1978

The rocket is used for launching Convair "B" seat from airplane. It consists of twin RP1 P1 L1 rocket motors manifolded together to provide maximum stability at launch with twin nozzles canted to thrust through CG of seat-man mass.

Performance data are: total impulse (sea level), 2,300 pound seconds; thrust time, 0.78 second.



Unit size is 4 by 10 by 18 inches (approximately). See Fig 214. Unit weight is 35 pounds (approximately).

Rocket Motor (Back Mount),
Talley Industries, P/N 50100

Proposed for the Martin-Baker seat, this unit has a design thrust of 5,500 pounds at 70°F with a burn time of 0.25 second minimum at 70°F. Its size is 2 by 3.75 by 21 inches. Estimated weight is 8 pounds.

Rocket Motor (Pan Mount),
Talley Industries, P/N 50101

Proposed for the Martin-Baker seat, has same performance as Talley P/N 50100. Unit size is 3.1 by 12.38 by 15.5 inches. Estimated weight is 17.75 pounds.

Boom Stabilizer,
Rocket Power, Inc., P/N's 1618 and 1619

Stabilizers are used to stablize the Convair "B" seat following ejection. Extension time is 75 milliseconds. Units are 2 feet, 4 inches long before extension. See Fig. 215. Units are 10 feet, 4 inches long after extension. See Fig. 216. Unit weight is 16.5 pounds each (approximately).

Stabilization System,
Talley Industries, P/N 90140

System was proposed for the Boeing ADO-12 airplane design separable nose capsule. System consists of two ballistically deployed booms with a 4-foot diameter first ribbon parachute attached to and deployed from each boom. The drag force on each parachute is 13,800 pounds maximum.

The boom and parachute stowage envelope is 8 inches diameter by 30 inches. Boom stroke is 60 inches. Parachute stowage volume is 650 cubic inches. The estimated system weight is 100 pounds.

Vertical Thruster (Propellant Powered),
Rocket Power, Inc., P/N 1610

The unit is a three-section telescoping tube thruster used to elevate the Convair "B" seat and man unit up and out of the cockpit for initial ejection. Stroke is hydraulically buffered for stroke control within human tolerance. The stroke is 28 inches (approximately). Unit will lift a 500 pound mass against a maximum 23,000 pound aerodynamic force in system.

The installed length of the thruster is 20 inches (approximately). See Fig. 217. Unit weight is 17 pounds.

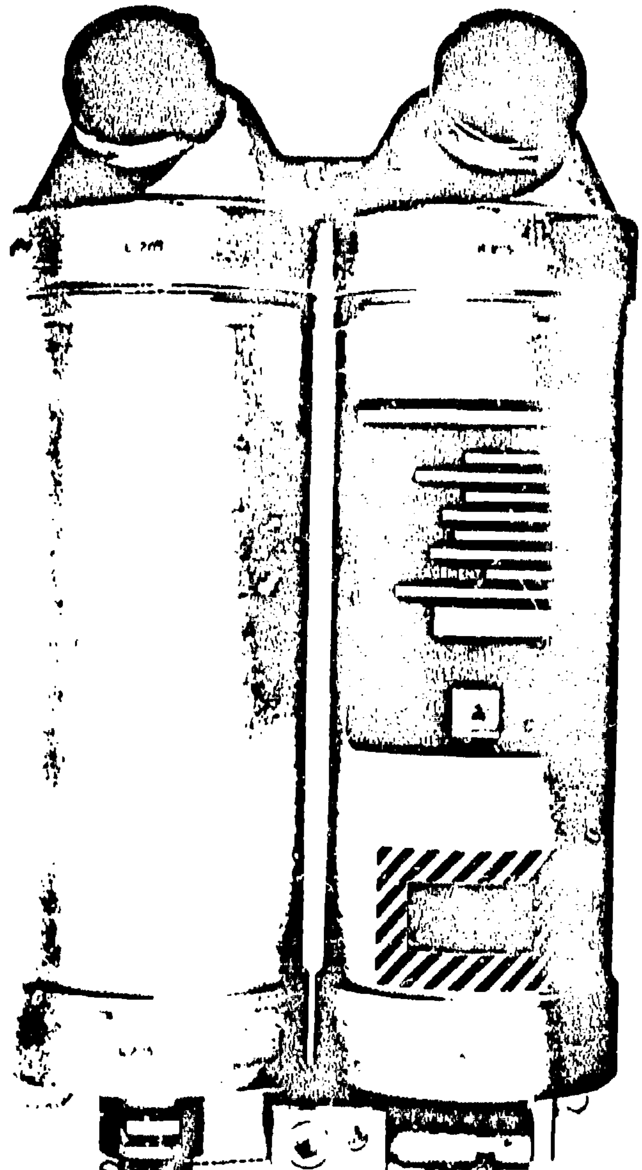


Figure 214. Escape Rocket – Rocket Power, Inc. P/N 1978

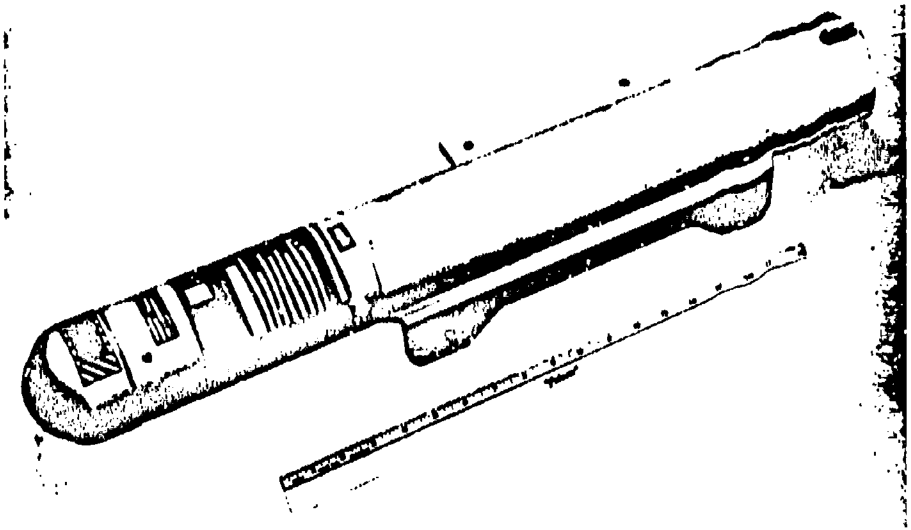


Figure 215. Boom Stabilizer (Retracted) – Rocket Power, Inc. P/N1618

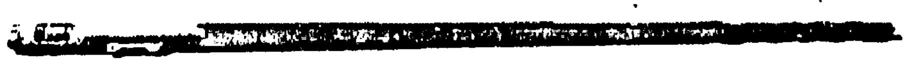


Figure 216. Boom Stabilizer (Extended) – Rocket Power, Inc. P/N1618

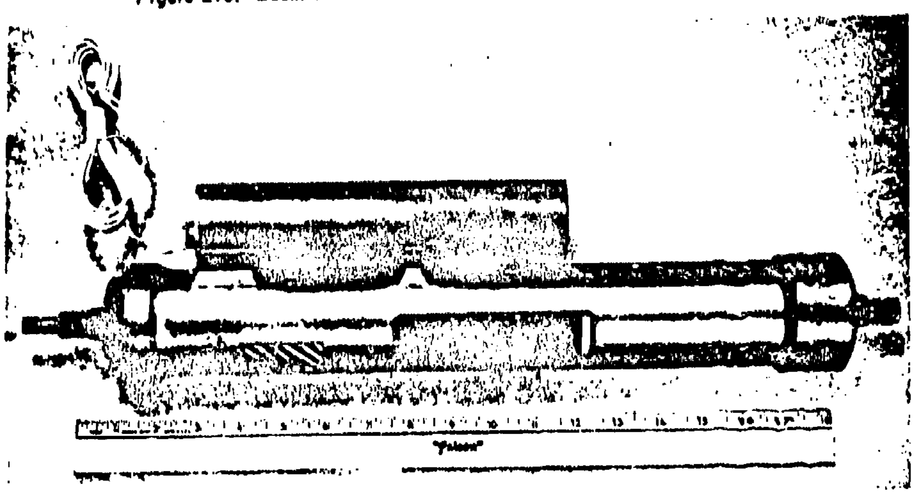


Figure 217. Vertical Thruster (Propellant Powered) – Rocket Power, Inc. P/N 1610

Rotational Thruster (Propellant Powered), Rocket Power, Inc., P/N 1612

Two of these hydraulically buffered thrusters are used to rotate the Convair "B" seat and man combination to a supine position as it emerges from the cockpit in readiness for launching. The stroke is 12 inches (approximately); operating time, 1.4 seconds; thrust, 510 pounds; acceleration, 3g; velocity, 11 feet/second maximum. The installed length of the thruster is 22 inches (approximately). See Fig. 218. Unit weight is 6 pounds.

Representative Frankford Arsenal Catapults

The catapult is a two or three tube telescoping device, containing an explosive component, designed for upward or downward ejection of crewmen and their seat from disabled aircraft. The following table presents principal characteristics of typical Frankford Arsenal Catapults.

Frankford Arsenal Designation	M3A1	M4A1	M5A1
• Number of tubes	3	3	3
• Length (inches)	51	31	39
• Diameter (inches)	3	2.6	2.3
• Stroke (inches)	88	45	66
• Weight (pounds)	24.9	6.7	8.2
• Propelled weight (pounds)	350	325	300
• Direction	Up	Down	Up
• Temperature limits (°F)	-65	to	+160
• Maximum acceleration at 70°F (g)	20	12.5	20
• Minimum velocity at 70°F (fps)	77	38	60
• Maximum onset rate at 70°F (g/sec)	180	100	170
• Firing method	Gas	Gas	Gas
• Cartridge	M36	M37	M28A1
• Stroke time at 70°F (seconds)	.24	.24	.22

Representative Frankford Arsenal Rocket-Catapults

The rocket-catapult is a two tube telescoping catapult device with an integral rocket motor, to provide sustained thrust, designed for "off-the-deck" as well as high-speed ejection capability. The following table presents the principal characteristics for some Frankford Arsenal Rocket-Catapults.

Frankford Arsenal Designation	M8	M9	M10
• Length (inches)	46.3	41.9	44.1
• Diameter (inches)	2.89	2.89	2.89
• Weight (pounds)	27	24	26
• Propelled weight (pounds)	350	350	400
• Temperature limits (°F)	-65	to	+160

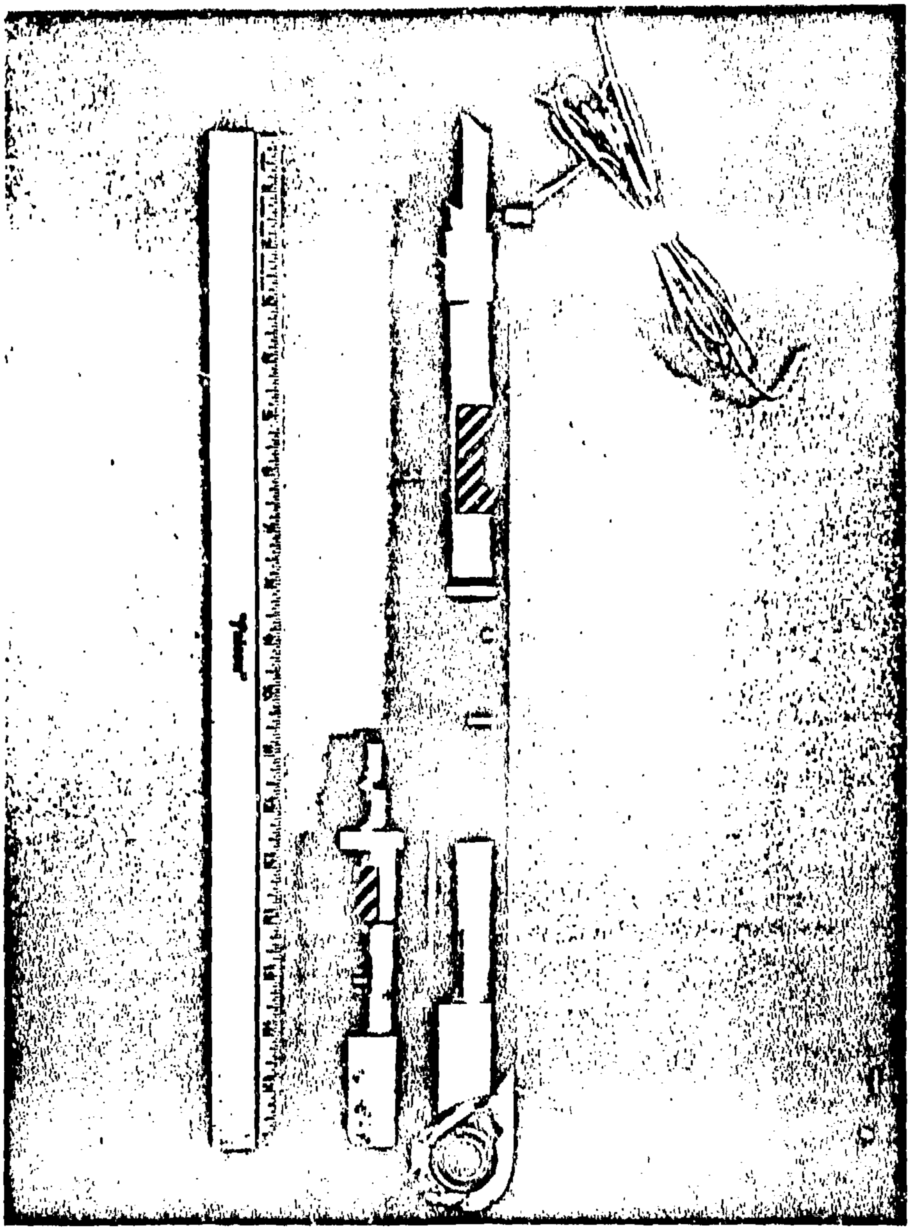


Figure 218. Rotational Thruster (Propellant Powered) – Rocket Power, Inc. P/N 1612

Catapult (booster section)	M8	M9	M10
• Stroke (inches)	40	35.75	34
• Maximum acceleration at 70°F (g)	20	20	20
• Velocity at 70°F (fps)	40	40	40
• Maximum onset rate at 70°F (g/sec)	300	300	350
• Stroke time at 70°F (seconds)	0.175	0.160	0.155
• Firing method	Gas	Gas	Gas
Rocket (sustainer section)			
• Maximum action time at 70°F (seconds)	0.4	0.35	0.4
• Impulse resultant at 70°F pounds-seconds	1,200	1,100	1,100
• Maximum pressure (psi)	4,600	4,600	4,600
• Maximum ignition delay at 70°F (second)	0.012	0.012	0.012
• Nozzle angle (degrees)	37.5	47.5	36.4

Figure 219 shows a cross-section and envelope drawing of the M10 rocket-catapult and Fig. 220 shows its operating characteristics. This unit is used on the F-104 aircraft to provide "off-the-deck" and high speed ejection capability.

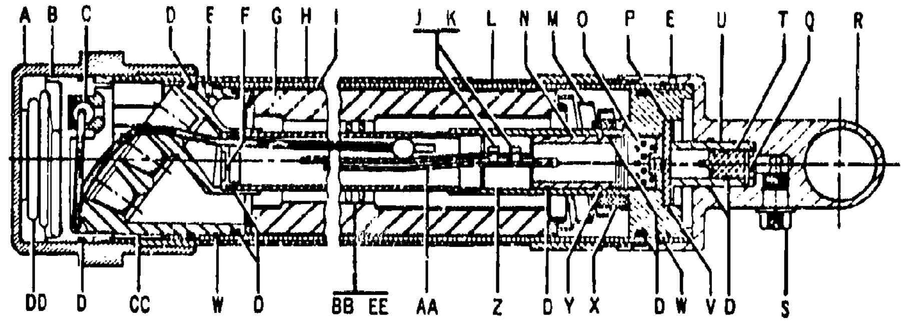
Frankford Arsenal Rocket-Catapult XM30

The XM30 rocket-catapult was developed by Frankford Arsenal as a direct retrofit for M10 catapults, but with rocket impulse increased to 2,300 pounds-seconds and with storage life and operational capabilities at 200°F. A novel feature of the design is a swivel, adjustable angle, nozzle which permits the catapult launching tube to be stored inside the rocket and functionally pass through the rocket nozzle. Immediately after exit of the launch tube through the nozzle, gas pressure, acting on a sleeve, causes the nozzle to rotate to a predetermined fixed angle. This design permits a 50 percent increase in propellant weight without an increase in installation diameter. Figure 221 shows a cross-section of the unit. Installation dimensions are the same as for the M10 rocket-catapult. Design data are:

• Catapult stroke	34.0 inches
• Nozzle angle	34° to 38° adjustable
• Rocket motor outside diameter	3.12 inches
• Overall length	41.5 inches
• Total impulse	2,500 pounds-seconds
• Performance range	-65°F through +200°F
• Weight	35.5 pounds

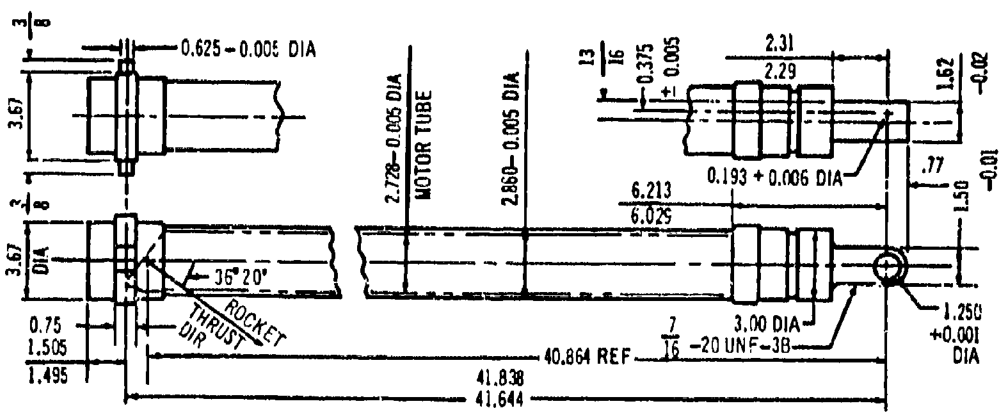
Representative Frankford Arsenal Thrusters

A thruster is a component of an aircraft escape system that is used to accomplish a certain task before implementing the final phases of the escape procedure. The basic parts of a thruster consist of a gas operated firing mechanism, cartridge, chamber, and piston. Each thruster is provided with an initial lock mechanism that is released when the cartridge functions. Thrusters have been developed with piston strokes between 1-1/2 and 13 inches.



CROSS-SECTION DRAWING

COMPONENT		COMPONENT	
A	BREECH, LAUNCHER TRUNNION	Q	PIN, SHEAR
B	CAN, BOTTOM	R	HEAD, MOTOR TUBE
C	HOLDER, CABLE LOWER	S	PLUG, SHIPPING
D	"O" RING	T	PIN, FIRING
E	SCREW, SET	U	SLEEVE, FIRING PIN
F	PLATE, ORIFICE	V	CAP, IGNITER RETAINING
G	PROPELLANT GRAIN, INHIBITED	W	WIRE, LOCK
H	TUBE, LAUNCHER	X	IGNITER, AUXILIARY ASSEMBLY
I	TUBE, MOTOR	Y	PIN, VALVE, SHEAR (4)
J	SCREW (2)	Z	CYLINDER, SLIDER VALVE AND TUBE BOOSTER ASSEMBLY
K	WASHER (2)	AA	HOLDER, STRIP LOADED ASSEMBLY
L	SLEEVE, HEAD	BB	COLLAR, GRAIN
M	SPRING, GRAIN	CC	NOZZLE ASSEMBLY
N	PISTON, SLIDER VALVE	DD	SPRING, CAN
O	IGNITER, PRIMARY ASSEMBLY	EE	SCREW SET (4)
P	RING, RETAINING		



ENVELOPE DRAWING

Figure 219. Frankford Arsenal M10 Rocket – Catapult

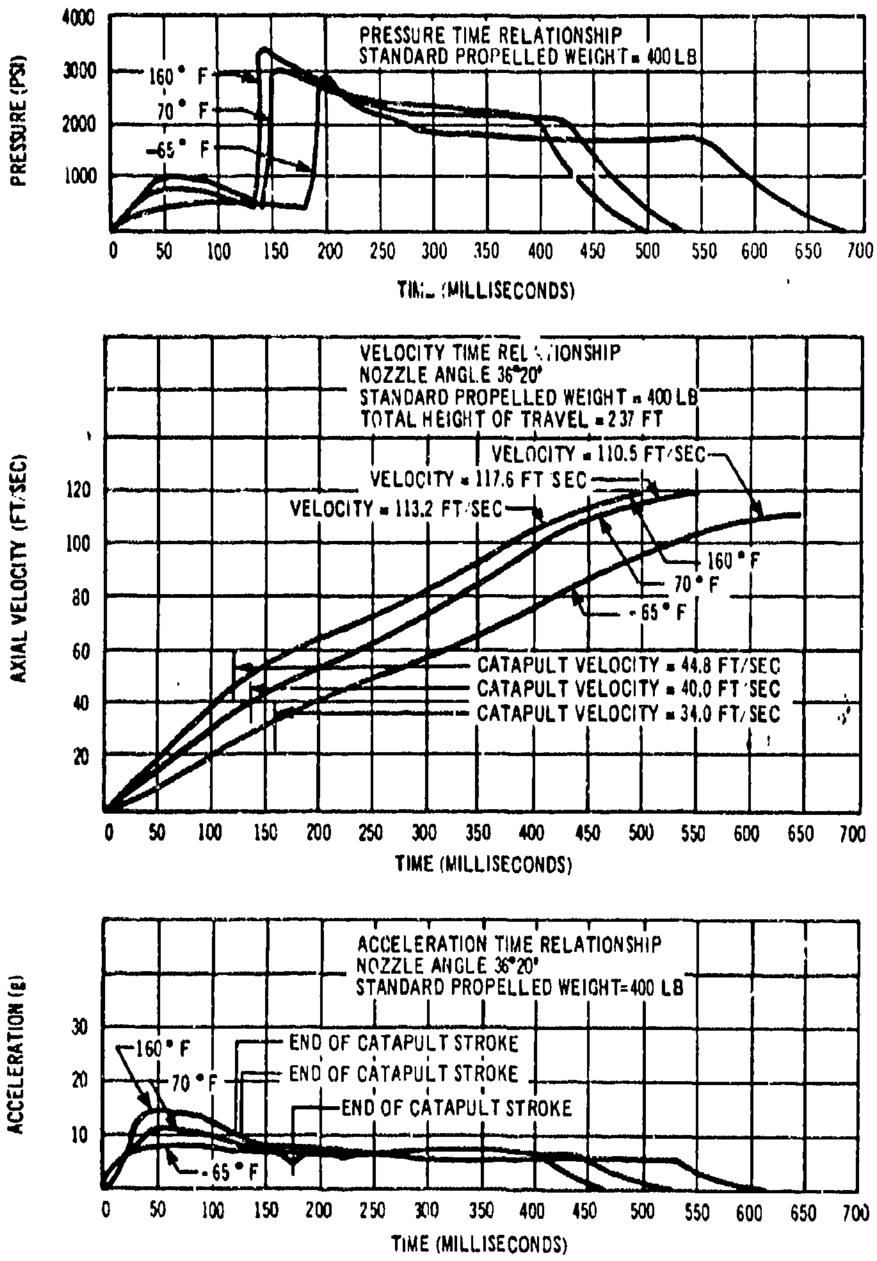
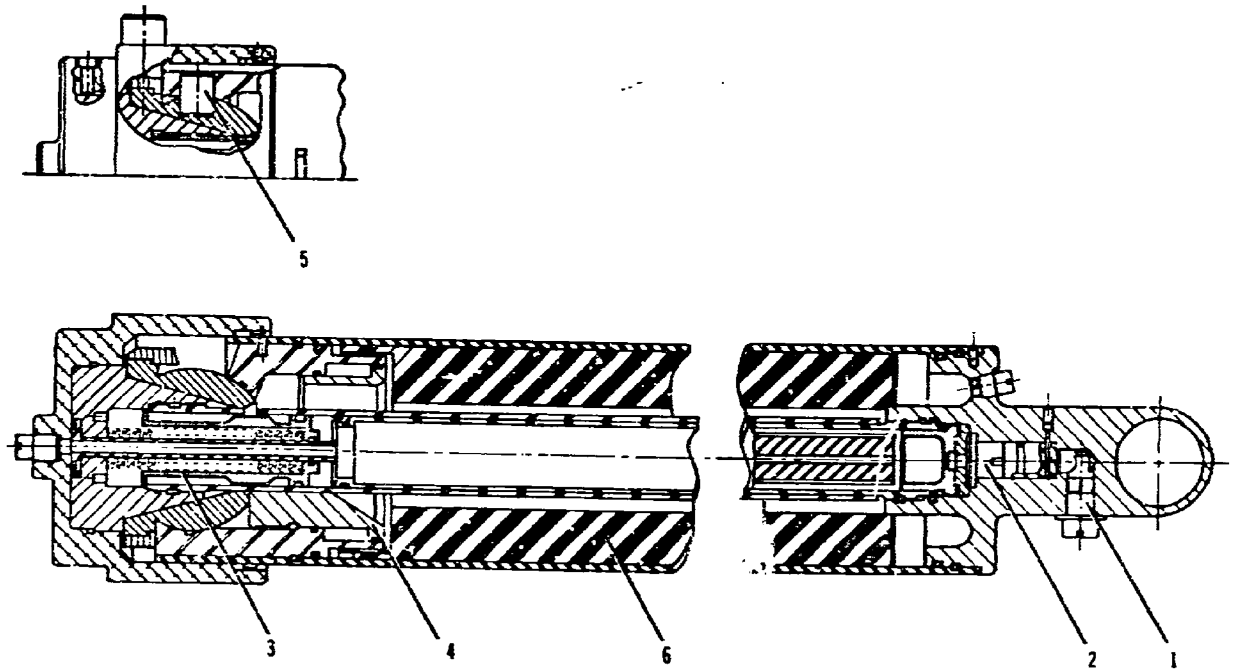


Figure 220. Frankford Arsenal M10 Rocket – Catapult Operating Characteristics



1 - GAS INLET
2 - CATAPULT CHARGE (CARTRIDGE)
3 - PISTON, RELEASE
4 - SLEEVE
5 - PIN
6 - ROCKET MOTOR

Figure 221. Frankford Arsenal XM30 Rocket– Catapult

Buffer or damper mechanisms are used with thrusters to restrict velocity and acceleration of the propelled load. Following are some typical examples of the Frankford Arsenal thrusters:

Frankford Arsenal Designation	M3A3	M17	M18	M20A1
• Length (inches)	9	25.37	21.69	12.6
• Diameter (inches)	1.07	1.82	1.82	1.4
• Peak thrust at 70°F (pounds)	1,660	1,660	1,080 at 160°F	5,880
• Completed stroke (inches)	1.5	13.25	9.5	5.0
• Weight (pounds)	1	13	12	3.6
• Propelled mass (pounds)	350	350	350	50
• Firing method	Gas	Gas	Gas	Gas
• Temperature limits (°F)	-65	to	+160---	+200
• Stroke time (seconds)	0.09	0.5	0.245	0.046
• Restraining force (pounds)	0	525	525	3,000

M3A3 used to release control column storage spring and operate seat actuator disconnect.

M17 and M18 used to position seat prior to ejection.

M20A1 used to jettison the canopy.

Representative Frankford Arsenal Canopy Removers

The canopy remover is a two- or three-tube telescoping device containing an explosive component, and designed to jettison the canopy from high speed aircraft before ejection of the crewman. Following are some examples of typical Frankford Arsenal removers:

Frankford Arsenal Designation	M2A1	M3A1	M4
• Number of tubes	2	2	3
• Length (inches)	31	31	14.67
• Diameter (inches)	2.19	2.19	1.93
• Stroke (inches)	26	26	19
• Weight (pounds)	4.4	4.4	3.8
• Propelled weight (pounds)	300	300	300
• Temperature limits (°F)	-65	to	+160
• Minimum velocity at 70°F (fps)	20.5	20.5	20.0
• Minimum thrust at 70°F (pounds)	2,600	2,600	2,800
• Stroke time at 70°F (seconds)	0.15	0.15	0.114
• Cartridge	M31A1	M31A1	M23A2
• Firing method	Mech.	Gas	Gas

Representative Frankford Arsenal Electro-Mechanical-Ballistic Removers

Electromechanical-ballistic removers are designed to raise and lower aircraft canopies under normal conditions during ground operation, and to jettison the canopy before ejection during an emergency. The following table gives the principal characteristics of the M8 and M9 Frankford Arsenal removers, designed for use on the F-106A and F-106B aircraft.

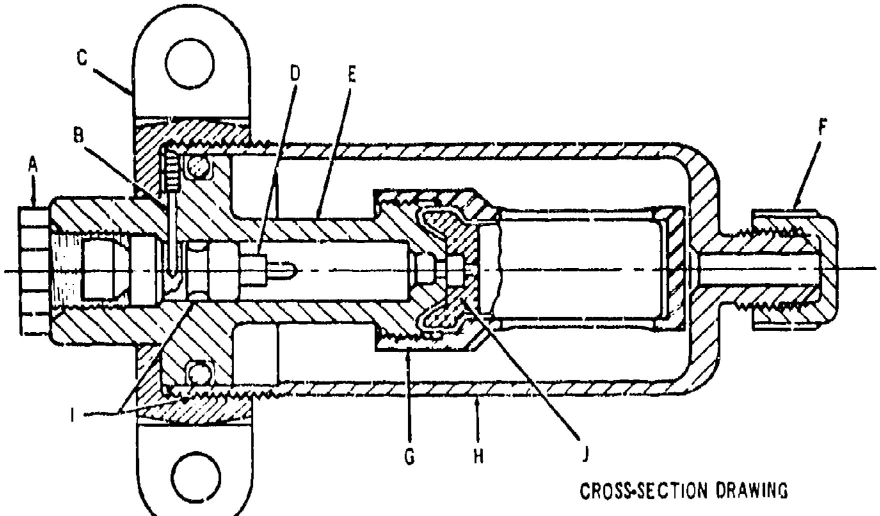
Frankford Arsenal Designation	M8		M9
Number of tubes	2		3
Length (inches)	20.25		27
Diameter (inches)	3.07		3.07
Weight including motor (pounds)	23		35
Temperature limits (°F)	-65	to	+200
Ballistic Performance			
Peak thrust (pounds)	6,000		6,750
Stroke length (inches)	12		24.5
Stroke time (seconds)	0.13		0.16
Propelled mass (pounds)	350		286
Maximum terminal velocity (fps)	25		44.4
Electromechanical Performance			
Stroke length (inches)	9.38		45.6
Stroke time (seconds)	9		17
Propelled mass (pounds)	350		286
Electric current (amps)	9		17
Electric voltage (volts)	28		28

Representative Frankford Arsenal Initiators

Initiators are used to provide actuating energy for the operation of firing mechanisms of other propellant actuated devices of aircrew escape systems. They are cylindrical devices consisting of a chamber with a pressure outlet port, firing mechanism, and cartridge. They are available with either mechanical or gas pressure actuation and time delays from 0.0 to 5.0 seconds. Also, they will deliver pressures up to 3,000 psi at the end of a 30-foot length of MS28741-4 hose, and will have various mounting provisions. The principal characteristics of some of the Frankford Arsenal initiators are as follows:

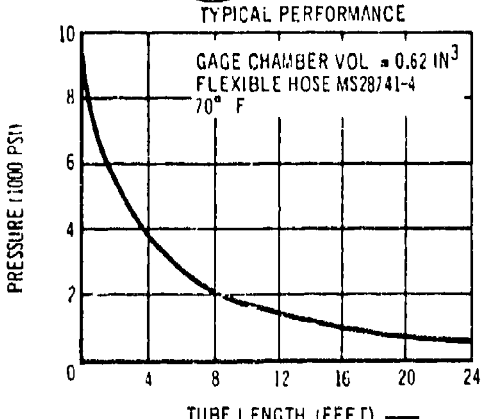
Frankford Arsenal Designation	M3A1	M4		M5A2	M6A1	M14 (Miniature)
Length (inches)	4.34	5.03		4.51	5.21	5.28
Diameter (inches)	1.38	1.38		1.38	1.35	0.876
Actuation method	Mech	Mech		Gas	Gas	Mech
Minimum actuation force (pound or psi)	40	40		750	750	40
Temperature limits (°F)	-65		to		+160	-65 to +160°F
Assembled weight (pounds)	0.9	1.0		0.9	0.9	0.39
Delay time (seconds)	0	2		0	2	3

Figures 222 and 223 show cross-section and envelope drawings and typical performance for M5A2 and M14 initiators.



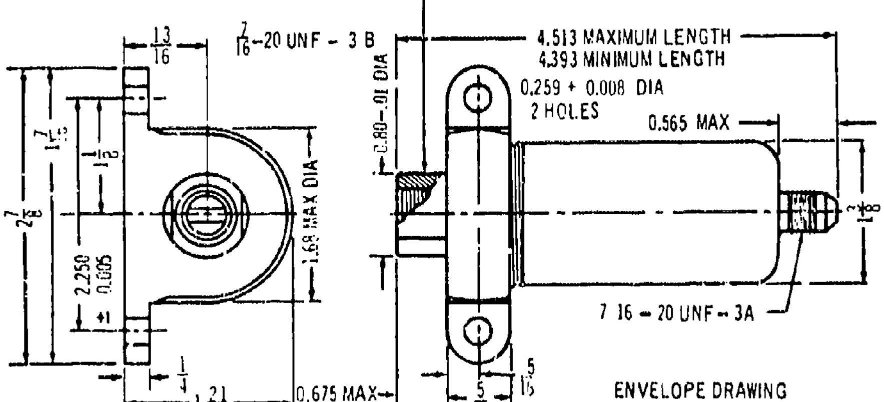
CROSS-SECTION DRAWING

TYPICAL PERFORMANCE



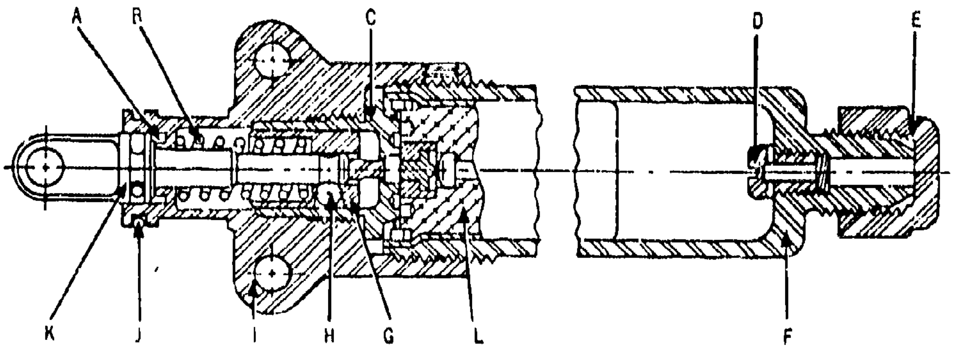
COMPONENT

- A PLUG, SHIPPING
- B PIN, SHEAR
- C CAP
- D PIN, FIRING
- E HOUSING, FIRING PIN
- F CAP, SHIPPING
- G CHAMBER, INITIATOR
- H RETAINER, CARTRIDGE
- I "O" RING
- J CARTRIDGE, INITIATOR, M73 ASSEMBLY

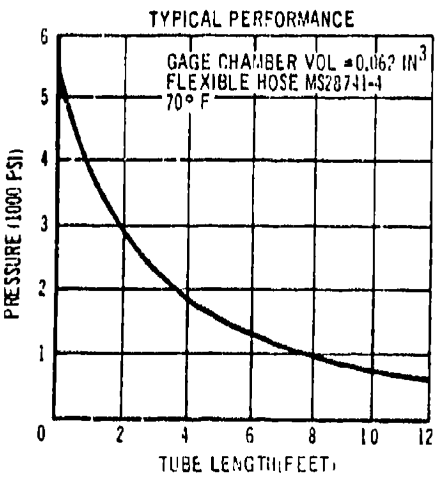


ENVELOPE DRAWING

Figure 222. Frankford Arsenal Initiator M5A2

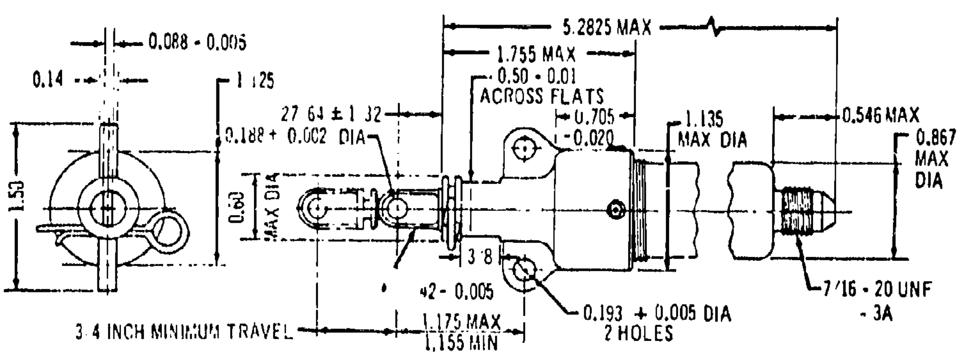


CROSS-SECTION DRAWING



COMPONENT

A	SEAL	G	PIN, FIRING
B	SPRING INITIATOR	H	BALLS (3)
C	HOUSING, FIRING PIN	I	CAP, INITIATOR
D	FILTER	J	PIN, SAFETY
E	CAP, SHIPPING	K	PIN, INITIATOR
F	CHAMBER, INITIATOR	L	CARTRIDGE, INITIATOR, DELAY, XM84 ASSEMBLY



ENVELOPE DRAWING

Figure 223. Frankford Arsenal Initiator M14

Inertia Harness Reel with Power Retraction, Pacific Scientific Co., P/N 0103114-2

Unit is applicable to the B-58 encapsulated seat. The inertia reel is normally installed behind the seat occupant. Dual straps pass forward over the seat occupant's shoulders and connect with his restraint harness. The inertia reel allows freedom of movement during normal operating conditions. The reel locks automatically when accelerations on the shoulder straps are in excess of 3g. A manual lock is also provided. Power retraction by a remote pressure source is initiated just prior to seat or capsule ejection. The occupant is retracted and restrained against the seat back and the reel is locked. The reel may be returned to normal operation after pressure has been released. Performance data are as follows:

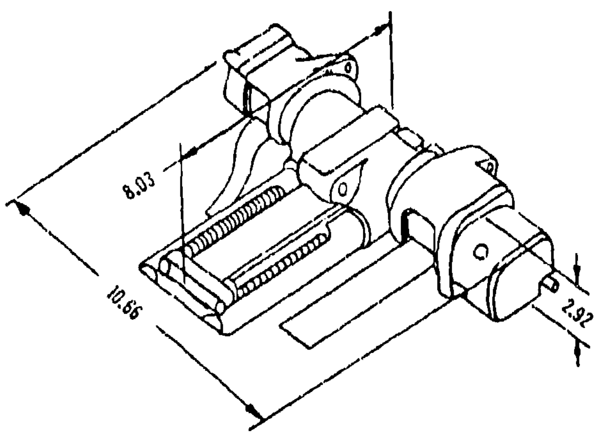
Normal Operation

• Strap extension	21 inches
• Strap tension	1 to 5 pounds
• Automatic lock setting	2 to 3g
• Ultimate load	3,300 pounds
• Temperature range	-65° to +150°F

Power Retraction Operation

• Operating pressure	1,000 psi ±15 percent
• Strap retraction	18 inches
• Retraction force	92 pounds
• Retraction time	0.3 to 0.6 second
• Reel-in velocity	12 feet/second maximum
• Peak acceleration	500g/second maximum
• Retraction stall force	100 pounds ±6 pounds per strap at extended position Just under 50 pounds per strap in the retracted position

A sketch of the unit showing its overall size in inches is shown.



d. PARACHUTE SYSTEMS

(1) Stencel Ultra Precision Parachute

The Ultra Precision Parachute (UPP) was developed by the Stencel Aero Engineering Corporation, Asheville, N.C. The UPP system incorporates internal ballistic energy sources for canopy deployment and spreading.

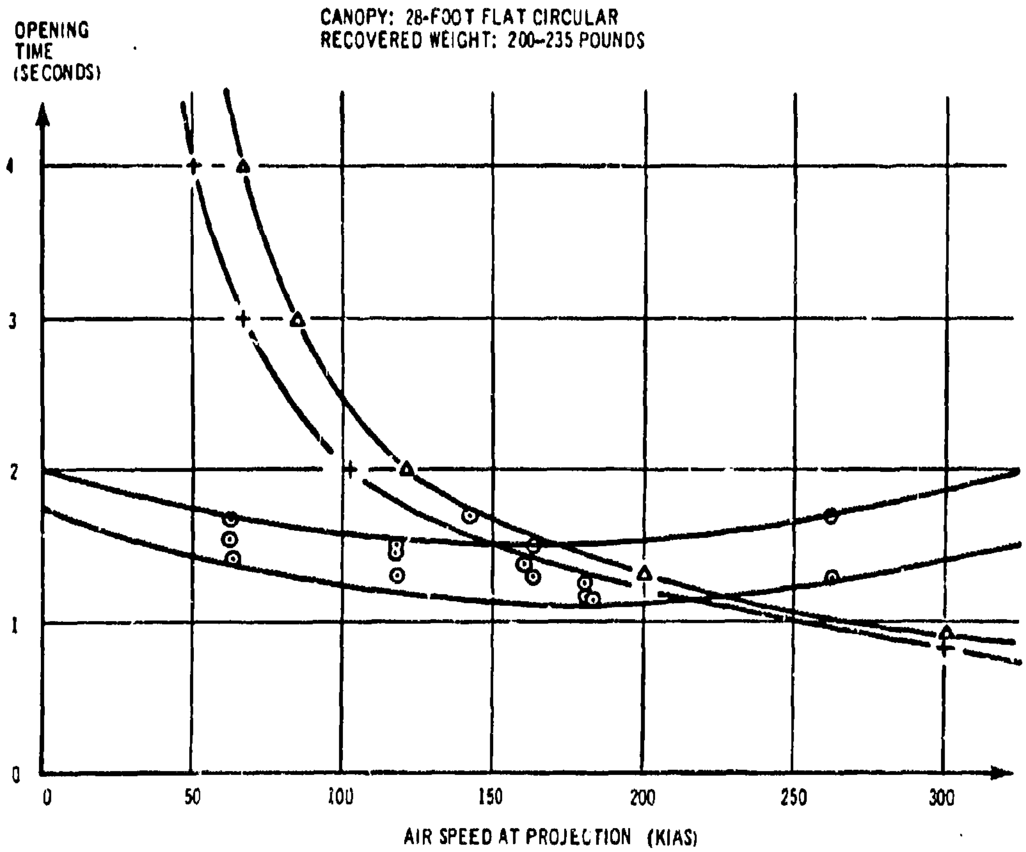
Under a U.S. Navy contract, a UPP for ejection seat recovery systems was developed incorporating the 28-foot flat solid personnel recovery canopy. The results of static and flight testing of this parachute, identified as the LS-1 Ballistic Parachute, are presented in Fig. 224. This figure also presents analytically determined opening times and inflation times for the same canopy with conventional deployment. In tests performed at zero air speed, the drop load was released to free fall at the same instant the LS-1 parachute was initiated. The canopy was fully inflated in less than two seconds. In flight tests, a stable 235 pound load was dropped from the test aircraft and the LS-1 parachute was projected at an angle of approximately 45 degrees to the airstream. The opening time of the UPP parachute is almost constant throughout the range of zero to 260 knots IAS as shown in Fig. 224. Although only two tests were performed at 260 knots, the desired upward trend of the curve appeared to be valid.

The UPP incorporates any standard canopy, although most work has been with flat solid canopies to which two ballistically powered guns are added. The first gun projects the pack to full line stretch. Line stretch is utilized to fire the second gun which spreads the canopy out of the pack. Any relative motion of the canopy to the airstream then produces rapid inflation of the canopy. The two guns are identified as the projection gun and the spreading gun, respectively. The LS-1 parachute shown in Fig. 225 is no larger than the parachute with conventional performance which it replaces. If required, the bulk of the UPP can be further reduced by special packing techniques, since the UPP with internal energy sources is readily adaptable to pressure or vacuum packing.

The performance characteristics of a given parachute can be controlled to a large degree by means of the amount of energy released in either one or both of the guns. Other controlling factors include the angle of pack projection with respect to the airstream, and timing the firing of the spreading gun. As a result, the performance characteristics of a parachute can usually be tailored to any specific system requirements.

The force time history of the LS-1 parachute when operated at air speeds above 170 knots has been successfully controlled. The results of a test in which the LS-1 parachute was operated at an air speed of 200 knots are shown in Fig. 226. The results of a test in which the LS-1 parachute was operated at an air speed of 150 knots are shown in Fig. 227. The peak deceleration force reduced slightly from the value at 200 knots air speed whereas the mean deceleration force was appreciably reduced.

T installed weight of the LS-1 parachute is 19.6 pounds. The projected weight . 8.0 pounds.



LEGEND: ⊙ TEST DATA ON UPP

Δ TOTAL OPENING TIME, CONVENTIONAL PARACHUTE (WADC 55-265), $t_o = t_f + t_s$

+ FILL TIME, CONVENTIONAL PARACHUTE (WADC 55-265), $t_f = \frac{8D_0}{v_s\ 0.9} = t_o - t_s$

Figure 224. Stencel Ultra Precision Parachute Operational Characteristics Test Data and Conventional Parachute Performance Data

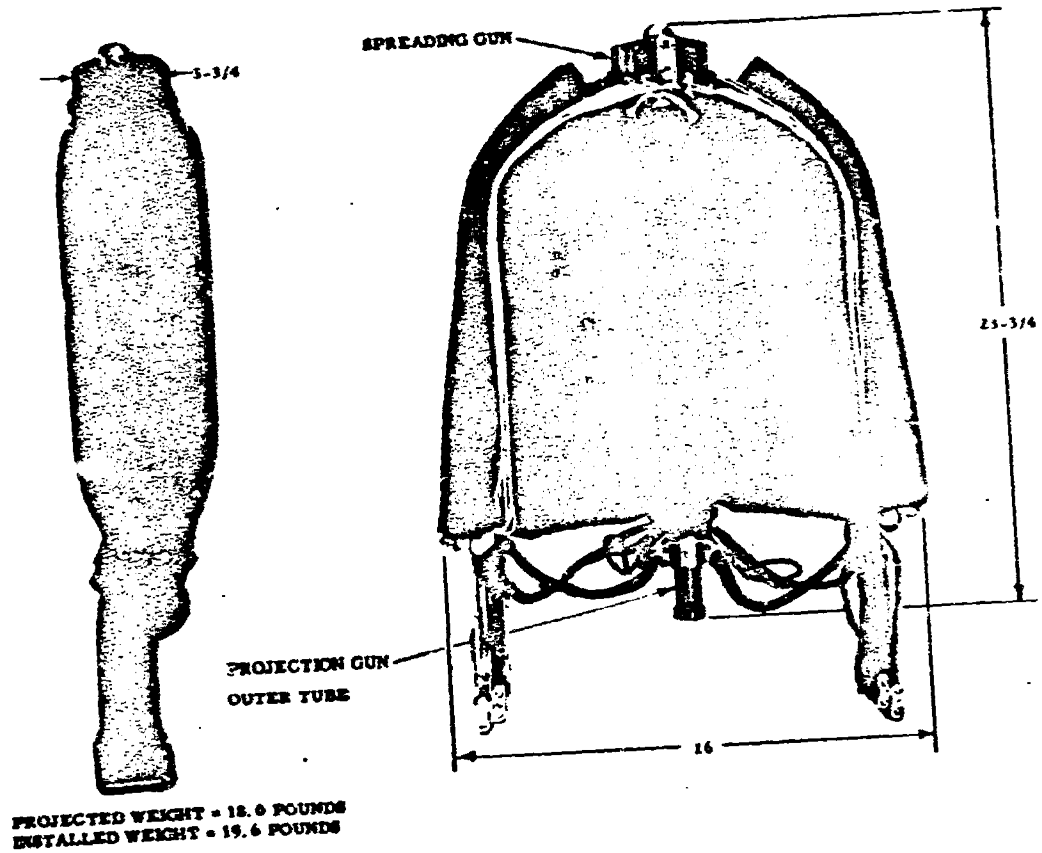


Figure 225. Stencel LS-1 Ballistic Parachute

(2) Weber Aircraft Corporation Ballistic Parachute System

The gun deployed personnel parachute is different from other parachutes in that the gun is within the pack. The gun fires a slug that deploys the pilot chute and the main canopy. The deployment gun is located in the upper right hand corner of the parachute pack and is aimed up and outboard at a 45 degree angle. There is a nylon strap attached to the slug with a screw and spacer. The strap is routed beneath the top protector flap to the manual override mechanism. The firing cable to the deployment gun comes out of the parachute on the lower left hand side of the parachute pack. The end of the cable has a special protective device and cover to prevent inadvertent actuation of the firing cable. The parachute can be deployed in the normal manner with the manual pull on the T-handle. Pulling the T-handle will not fire the deployment gun. Pulling the special end fitting on the firing cable after the special housing on the end of the outer housing is retracted will fire the deployment gun.

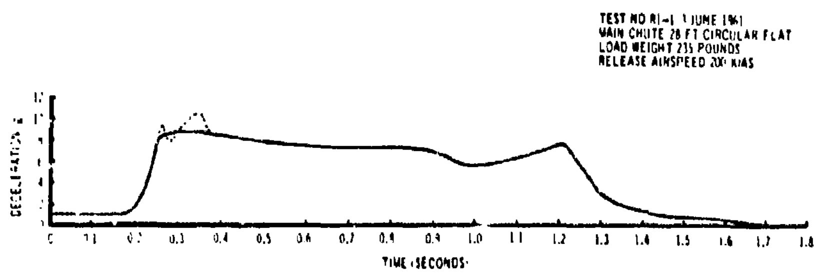


Figure 226. Stencel LS-1 Ballistic Parachute Deceleration versus Time

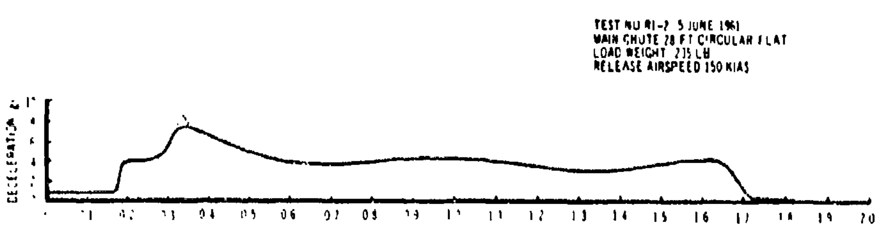


Figure 227. Stencel LS-1 Ballistic Parachute Deceleration versus Time

e. LIFE SUPPORT SYSTEMS

(1) High Altitude Full Pressure Suits

With the advent of military requirements for high altitude flying, a variety of high altitude pressure suits have been developed to allow crew members to survive in atmospheres that would not normally support life. At altitudes above 35,000 feet, oxygen must be delivered to the lungs under pressure; however, by the time an altitude of 45,000 feet is reached this pressure will attain an equivalent value of about 12 inches of water, rendering breathing difficult if no compensatory pressure is applied to the external trunk of the body (Ref. 7). Above 63,000 feet another barrier is encountered. The atmospheric pressure drops to a point where boiling of the blood would occur unless counter pressure is applied. Full pressure suits developed by both Air Force and Navy have prevented these problems.

Air Force Full Pressure Suit A/P22S-2 — description of this suit was gathered from Refs. 8, 9, 10, and 11. The Air Force A/P22S-2 full pressure suit is designed to maintain an internal pressure of 3.96± 0.2 psia (equivalent to ambient pressure at 35,000 feet) at altitudes up to 100,000 feet, while delivering oxygen to the wearer and rendering pressure breathing unnecessary.

The suit helmet, Model HGK-13/P22S-2, weighs 5-1/2 pounds and consists of three basic components: 1) a hard plastic outer shell providing protection and pressure retention, 2) an internal rubber bladder providing counter pressure, 3) a transparent faceplece. Helmet diameter is approximately 14 inches. Oxygen flow into the face area is regulated by a positive pressure demand type regulator designed to operate in the pressure range of 50 to 90 psia, while pressure within the oral-nasal cavity of the helmet is maintained within the range of 0.0 to 1.5 inches of water throughout the flow range of 0 to 100 LPM. A neoprene-foam rubber face seal is positioned on the inner support frame of the helmet, sealing the face area off from other suit cavities. A spring loaded exhalation valve, mounted on the face seal, routes exhalation gases into the suit. Standard equipment includes foam-rubber earphone cups and adjustable microphone. In many models the communications cable supplying these two components has been integrated with the oxygen line. A plexiglass front piece is hinged on each side and can be opened to a position on top of the shell or closed over the face. A sun-glare visor is located at the same position and may be superimposed over the clear plate. The ring bearing disconnect, located at the base of the helmet shell, is used for attachment of the helmet to the suit.

The coveralls, Model CSK-6/P22S-2, weigh 11 pounds and consist of four distinct protective layers: 1) a polyurethane coated nylon cloth outer layer, 2) a dacron link-net restraint layer with a single wall distensible bladder of neoprene-coated nylon underneath, 3) a ventilation layer attached to, 4) the innermost layer which contains channels for air distribution to the extremities and upper torso. The suit has been designed to accommodate a full standing position, a feature lacking in many of the earlier models.

Gloves (weight, 1 pound) connect to the suit at the wrists by disconnect rings or zipper, and consist of a leather and nylon outer shell with a single-wall distensible bladder flocked on the inside. Flocked neoprene pressure socks are cemented to the suit legs. Conventional flight boots are worn over these.

Three, and sometimes four, life lines are attached to the suit. The ventilation air inlet hose is attached to the left front of the suit while the suit pressure controller is mounted on the right front. The controller functions as a pressure sensing and flow control device which senses pressure changes within the cockpit and restricts ventilating air accordingly, opening to allow gas loss when an internal pressure of 5 psi is reached. The controller can also sense loss of suit ventilating air and direct either aircraft or emergency system oxygen through the suit for pressurization. (See Fig. 228.)

Navy Full Pressure Suit Mark IV — description of this suit has been gathered from Ref. 12, 13, and 14. Although research is currently being conducted with regard to development of an improved full pressure suit, the Mark IV is considered adequate as a pressure/oxygen system for current naval aircraft. The suit is designed to maintain an internal pressure of 3.35 ± 0.2 psia at altitudes up to 100,000 feet when cabin pressure is lost above 35,000 feet, while supplying oxygen to the crew member.

Helmet Model GF 70, or GR 90, weighs 5 pounds and contains systems and components nearly identical to those found in the Air Force HGK 13/P22S-2 model. The helmet is secured to the suit through a ball bearing neck ring, which permits the wearer to rotate the helmet, providing about 240 degrees of visibility from side to side.

The coveralls weigh 11 pounds and consist of two discrete layers: 1) a reinforced rubber inner bladder, and 2) a nylon outer fabric. A series of straps run across the shoulders and chest, reducing ballooning. As on the Air Force coverall, a set of lacings run up the back of legs, arms, and torso providing adjustment capability. The suit pressure controller, whose function is identical to that on the A/P22S-2 suit, is located in the seat pack. Ducts supplying ventilation air to the suit are attached to the inner bladder, distributing air to the wrists, ankles, groin, and torso area.

Gloves (weight, 8 oz.) are constructed of suit material with soft leather sewn over the palms and fingers. A wire is imbedded in the palm and secured to the back of the gloves to prevent ballooning and to increase dexterity. Leather boots fit over the rubber feet of the suit.

Both suits are pressurized automatically by means of the suit pressure controller and the helmet mounted breathing regulator whenever the cabin altitude reaches 35,000 feet (Fig. 229). The helmet breathing pressure regulator monitors suit pressure and is pre-set to deliver oxygen to the helmet face area, at a pressure slightly greater than that of the suit, in order to preclude entry of suit gas into the oral-nasal area.

The complete suit weighs between 17 and 25 pounds depending upon length and type of hoses used, boots and gloves worn, etc. An experienced pilot should be able to don either suit in about 10 minutes. This includes putting on the long underwear which is always worn beneath the suit.

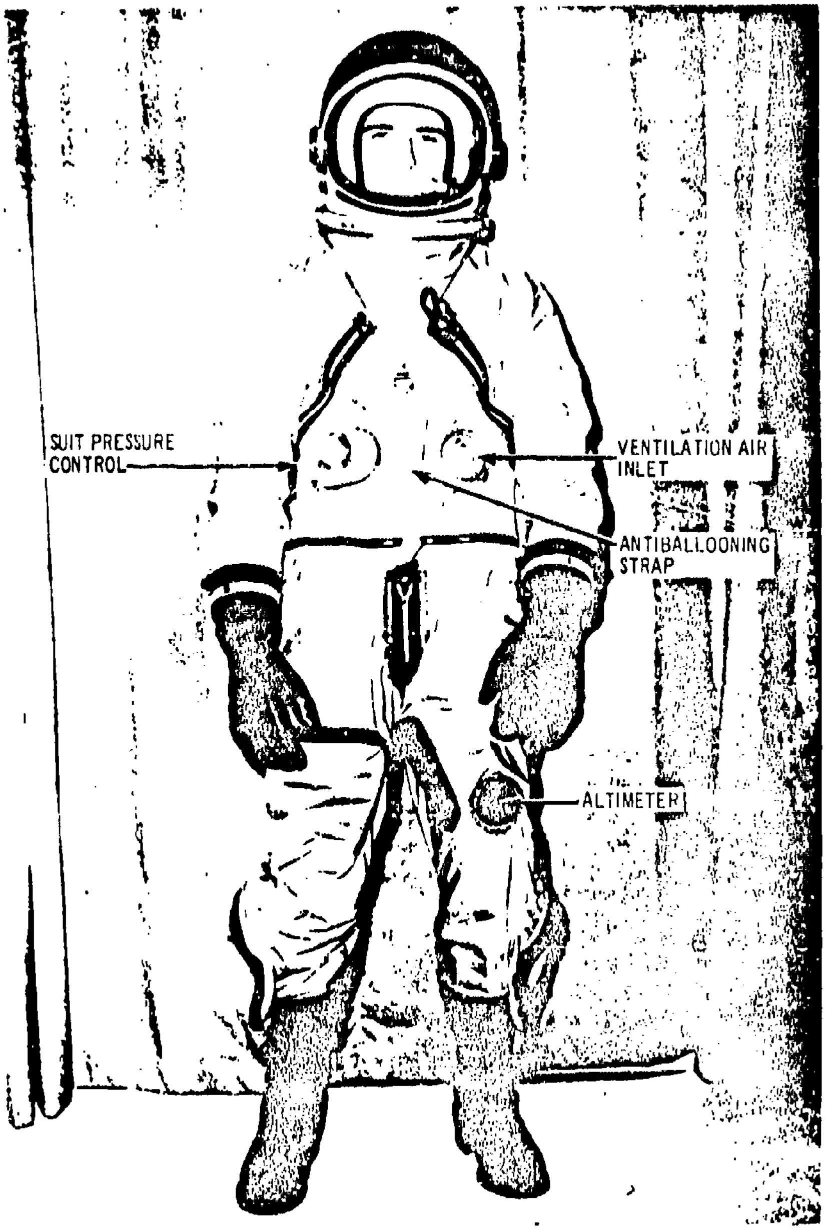


Figure 228. USAF A/P22S-2 — Full Pressure Suit

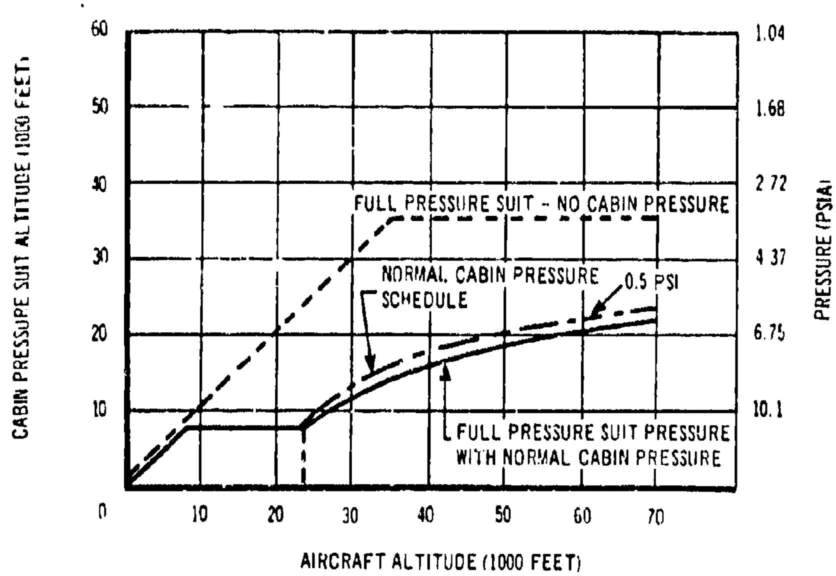


Figure 229. Pressure Suit Altitude – Pressure Schedule

Suit pressure/temperature air system gasses emanate from two sources: 1) the air conditioning system which usually consists of a heat exchanger and an expansion turbine, with shutoff and pressure regulating mixing valves, providing refrigerated air which is mixed with 2) bleed air from either or both engines. Gases from this system are fed into the pressure suit at a temperature selected by the wearer. Should this pressurization system fail, the pressure control valve would automatically close, preventing loss of gas from the suit; repressurization would be instituted through the oxygen system (Ref. 9).

Both Air Force and Navy full pressure suits have been worn by over 150 individuals in simulator tests and evaluation flights. The following tests and results were recorded for the two suits (Refs. 9, 15, and 16).

Altitude Chamber Tests — individuals were exposed to simulated altitudes ranging from 7,000 to 100,000 feet for time intervals of 5 minutes to 2 hours. Explosive decompression was simulated from 25,000 to 65,000 feet in about 1 second. The suits adequately maintained the pressures required by the wearer for survival. Although the decompression effects were unpleasant, no extreme discomfort was noted.

Low Speed Parachute Jump Tests — these tests have been conducted utilizing 10 and 25 seconds of free fall from 16,000 and 10,000 feet respectively before chute deployment. The suits proved to be satisfactory.

Windblast Tests — the suits were subjected to high speed windblast sled tests ranging from Mach 0.68 to 1.08. High speed ejection tests have also been conducted where ejection was accomplished from an F-106 aircraft at 22,000 to 23,000 feet and air speeds of 730 knots (Mach 1.58). The suits withstood these windblast subjections in a satisfactory manner.

Thermal Evaluation — pilots wearing a full pressure suit have experienced temperatures of -25°F with windblasts up to 30 mph without adverse effects, while test subjects wearing full pressure suits were able to withstand a 30-minute stay in water of 33°F coupled with a period of 75 minutes on a rubber raft where air temperature was 10° to 21°F. Subjects indicated a possible tolerance of 5 to 6 hours under these conditions while wearing a suit. It was noted that the suits floated quite well with air trapped inside and were watertight; however, regular flotation equipment was required.

The extreme importance of obtaining a proper fitting suit was emphasized since air and water leakage occur when the suits fail to fit well. Extra equipment suggested for exposure protection included:

- 2 suits of long underwear
- 2 pair wool socks
- 1 pair mukluk boots
- 1 combisuit
- 1 pair thermal rubber boots
- 1 pair exposure mittens

Impedance of pilot task performance while wearing a full pressure suit has, in some instances, been slight while in other situations the performance decrement has been quite large. Gross tasks such as knob turning and lever pushing are affected very little by the unpressurized suit, while pressurization introduces a degree of cumbersomeness and a fatigue factor which are significant in pilot performance. Subjects who were asked to perform tasks of finer resolution with the Purdue Peg Board while wearing a pressure suit showed a decrement in dexterity of 35 to 65 percent depending on whether the suit had been inflated, (Ref. 17).

Pilots at Selfridge Air Force Base, Michigan, reported that restricted mobility while wearing the pressurized suit made it difficult to actuate fuel switches, armament recycle buttons, M-A-1 power switch, and manually tune the UHF radio.

Target acquisition through an optical sight is very difficult when a suit is worn, face plate glare and interference make it difficult to get a full field of view. Glare has been found to be a real problem when flying on top of an undercast when the sun is forward at the 3 or 9 o'clock position, while scope interpretation is difficult to impossible when flying into the sun (Ref. 18).

In one test, pilots wearing the suit found that glare from the helmet visor was a contributing factor in lowering pilot efficiency. In this instance it was listed as the direct cause of 6 missed intercepts out of 205 that were attempted.

During formation flying, most pilots complained about the restricted mobility that prevented the flight leader from seeing his wing man; the inability to quickly trim the aircraft because of the gloves, and the always present fatigue factor. Periods of high humidity caused a fog problem with the face plate.

Examination of sweat patterns of pilots wearing the suits for 3-hour periods or longer has shown that ventilating air within the suit is generally not adequate to meet the heat removal demands of the wearer. With extended use, the suits soon become filthy and odorous. To date, no competent cleaning procedure has been devised to overcome this problem.

Weather flying or night flying in the suit has created no problems, and no physical, psychological, or mental problems have been found in connection with the suits.

One of the main problems with the suits seems to be the longitudinal stretching which occurs with pressurization. The helmet is pushed off the top of the suit and the gloves have a tendency to elongate one to several inches past the finger tips, decreasing manual dexterity and increasing fatigue.

In tests conducted by the 94th squadron, Air Defense Command, Selfridge Air Force Base, during which 135 sorties were flown in the A/P22S-2 pressure suit, the following conclusions were made:

- The suit is too uncomfortable to permit continuous wear during alert, or for periods in excess of 6 hours.

- Pilots do not want to wear the suit for anything other than sustained flight above 50,000 feet.

- A five-minute scramble is almost an impossibility.

- The pilots ability to react to a serious emergency would be degraded by the suit.

- The suit should not be used in combat.

- Training flights in the suit should be continued on a limited basis.

(2) Antiexposure Clothing

Aircrew antiexposure clothing plays an important role in the success or failure of many missions, as well as providing an element of survival for the crew following ejection. Light to medium weight garments are presently available which are fully effective within established temperature limits. Pilot acceptance of these suits has been good, whereas the heavier suits have not been well received due to ventilation requirements, the comfort factor, degradation of mobility, etc.

The development of arctic survival clothing has been hampered to some extent due to a lack of adequate insulation material. Several models affording protection from arctic environments are now available; however, these have not proven to be entirely adequate since the Air Force Life Support Systems Program Office continues to show an interest in the development of an antiexposure garment capable of providing protection at -65°F which would also be fireproof, waterproof, and lightweight.

The following antiexposure garments are considered representative of those found in Air Force and Navy stores. For a more complete compilation see Refs. 19 and 20.

Lightweight Antiexposure Clothing — Air Force Flying Coverall, CWU-1/P (Ref. 22). This lined, one-piece suit provides lightweight protection for flying personnel operating in the temperature range of 35°F to 85°F. The outer shell is nylon twill while the inner lining is rayon faced wool-backed cloth. A nylon hood retracts within the fabric collar when not in use. Suit closure is effected with a zipper extending from the crotch to the neck. Suit weight is less than 4 pounds, making it simple to don and providing ease of movement.

Navy Winter Flying Suit (Ref. 20) — The two piece suit (jacket and trousers) is made in three layers of fabric: 1) an outer shell of water resistant nylon, 2) middle insulating layer, 3) inner lining. The suit comes equipped with a detachable fur-lined hood. Suit weight is less than 5 pounds.

Regulation flight boots and gloves are worn with both the above suits.

Heavy Duty Antiexposure Clothing

Air Force Heavy Duty Suit (Ref. 21). This antiexposure assembly consists of four discrete layers: 1) long underwear, 2) ventilating garment, 3) inner garment, 4) outer garment. The MA-3 is a one piece garment without sleeves and with open legs, made of 2 layers of flexible vinyl, the surface of which is cross-corrugated into a fine waffle-weave pattern which facilitates ventilating airflow between layers and along the outer surfaces. Air is blown between the 2 vinyl layers, through the air inlet hose at the front, and reaches the body through numerous specially arranged small holes in the inner layer. In flighting, the garment may be ventilated with air from the system within the aircraft or from a small lightweight blower (4 in. x 8-1/2 in., weighing 3-3/4 lb) that can supply air for two suits. During standby, the garment may be ventilated with the small blower, or with a large blower which can supply air to 12 garments. The inner garment (CWU-2/P), worn over the ventilating garment, is primarily an insulation garment for the outer coverall. It may also be used as a separate flying coverall in the temperature range of 14°F to 40°F. It is fabricated from 2 layers of wool-backed-nylon with portals for the hoses of the ventilating and anti-g garments located in the front. A separate hood of single-ply wool-backed-nylon accompanies this suit along with leather combat boots. The outer garment (CWU-3/P), consists of the CWU-3/P coveralls, permanently attached FWU-2/P overshoes, a separable protective hood, and neoprene-coated, water-repellent fabric mittens.

The antiexposure overshoe is designed to fit over the standard, ankle-high service shoe, or the 10-inch leather aircrew flight boot.

Air Force/Navy-R-1A Quick Donning Antiexposure Coverall (Ref. 19). This suit was designed to protect personnel from immersion in water as well as arctic snow conditions. In addition, the suit provides the wearer with buoyancy to keep afloat until a life raft can be reached. The R-1A is a one-piece coverall constructed of rubberized nylon. An attached hood is optional. The suit completely encases the users body with the exception of the face and hands, and may be donned in 30 to 40 seconds over regular flight clothing by an experienced airman.

Navy Antiexposure Suit MK-4 (Ref. 20). This watertight suit provides warmth under extremely cold conditions and buoyancy in case of emergency bailout or crash landing at sea. The suit consists of: 1) an insulation liner which consists of the two-piece navy winter flying suit described under lightweight antiexposure clothing, and 2) a waterproof outer garment. Rubber wrist and neck seals are part of the suit, combined with the attached MK-4 boot.

The suit and liner have given protection from exposure for two hours in water at 28°F and in subzero weather on land for several hours. There is, however, no ventilation capability within the suit, and its bulk (approximately 15 pounds) makes it less desirable than the MK-5 suit.

Navy Antiexposure Suit, MK-5. The two-piece garment consists of 1) an inner suit consisting of a one-piece nylon twill coverall with built-in ventilating capability furnished through ducts woven into the fabric, and 2) an outer layer, very similar to that of the MK-4; however, improved wrist and neck seals along with improved mobility make the suit more desirable. Total weight of the MK-5 is approximately 10 pounds. Hose attachments for the anti-g and ventilating garments are located waist high on the left front of the suit.

Down-Filled Arctic Exposure Clothing (Ref. 22). A down-filled, nylon covered, winter survival ensemble has been developed by the Gerry Mountain Sports Company and is currently undergoing evaluation tests at WPAFB. It consists of the following items:

- Walk Around Sleeper — semimobile sleeping bag which is designed for walking and working as well as sleeping. Weight, 3-1/2 pounds.
- Mittens — weight, 6 ounces.
- Overboots — used for both lower leg and foot protection, not for walking. Weight, 1 pound.
- Wind Pants — extra leg protection. Weight, 4 ounces.

The above ensemble weighs 5-1/4 pounds, and hand stuffs into 900 cubic inches or vacuum packs into 350 cubic inches. In lieu of the walkaround sleeper, the following items may be used:

- Combination Coat — used as a short coat which snaps around the upper part of the legs individually, or forms top half of sleeping bag. Weight, 3 pounds.
- Waist Sack — half length sleeping bag for use with the combi-coat. Weight, 1-1/4 pounds.
- Wind Parka — for use with the combi-suit. Weight, 8 ounces.

These garments, when worn together, have been found to be adequate in cold chamber tests of -40 degrees and to provide a body CLO value of 5.25. The suits' limitations are:

- Some manual control is necessary to maintain down distribution while the garments are being worn.
- When sleeping directly on snow, the insulation of a parachute or other material must be used underneath the wearer.
- The nylon covering of the garment will melt at 482°F, care must be taken around open fires.

(3) Locator Beacons and Transceivers

At present there exists an inadequacy in emergency locator devices. Some of the problems involved are lack of dependability, unsatisfactory modes of actuation, lack of standardization of existing models, and non-availability. In addition to this, the Air Force has expressed a desire for development of a discrete radio signal system, because those in use at the present time may be monitored by enemy as well as friendly forces.

The following locator devices are presently being employed by the military and are considered to be representative of equipment available to Air Force and Navy aviators.

Air Force Radio Devices

AN/URC-10, a waterproof solid state transceiver operating in the frequency band of 240-260 mc. May generate a sweep audio tone beacon mode, which can be locked in for unattended operation, or provide a CW signal for location by homing devices. The transceiver is equipped with a telescoping antenna, measures 5-3/4 by 1-1/4 by 3 inches, weighs less than 27 ounces, and can be operated in one hand. The dry battery is carried in a separate metal holder, similar in size to the transceiver, and weighs 36 ounces. It is connected to the transceiver by 2-1/2 feet of cable. The transceiver will operate on a 50 percent transmit-receive duty cycle for 70 hours. The set will operate within the temperature range of -55° to +55°C. Its signal is reliable to an altitude of 20,000 feet, and has a range of 100-150 miles.

RT-285A/URC-11. A waterproof battery operated transceiver with transistorized audio system and telescoping antenna. The transceiver provides for the transmission and reception of CW, modulated CW, and voice signals on a frequency of 243.0 mc., permitting location by homing devices at a range of approximately 100 miles and an altitude of 10,000 feet. Voice communication is possible within a range of 65 miles. The battery has an operational life of 24 hours (50 percent transmission). Weight of the complete set is 3-1/2 pounds. When used in an ejection capsule, the operational life and utility of the URC-11 radio may be greatly enhanced with the installation of an automatic, externally mounted antenna. Four BA-1315 batteries installed within the capsule provide radio transmission life of over 500 hours. Modification of the radio also allows standard headphones to plug into the set, providing voice reception from the moment of ejection. The radio, in operational condition, may be removed from the capsule by unlocking a hand operated snap (Ref. 23).

AN/URT-21 (Ref. 24). This miniature transmission beacon is normally housed in an open end pocket in the parachute; however, it may be carried in the shirt or pants pocket since complete set size is only 5-1/2 x 3-1/2 x 1-1/2 inches with a weight of 18 ounces. Opening of the parachute activates the chute mounted set; the antenna is incorporated within one of the parachute risers. The set will transmit a constant beacon on a frequency of 243 mc. for 24 hours at an 80-mile range to aircraft at 10,000 feet altitude. This beacon is currently being used by the Tactical Air Force. A lighter model (URT-27), with the same range, has been proposed by the Air Force and should be in production by 1966 .

Navy Radio Devices

AN/PRC-49 (Ref. 25). A two-way voice radio beacon with an operational life of 24 hours on the 243 mc. guard channel. Total weight, including battery, is 3 pounds, with the battery in a separate package. Range varies with antenna configuration, but is from 20 to 60 miles within line of sight distance. This set can be stowed on the airman or in the survival kit. The newer PRC-63 radio which is nearly identical to the PRC-49, except that it can transceive with the Air Force URT-27, is being procured by the Navy.

AN/URC-39 (Ref. 25). Personal two-way voice radio plus beacon which operates on 243 mc. Operational life is 24 hours with a range of 20-60 miles to aircraft at 10,000 feet altitude. Weight is approximately 2 pounds.

AN/CRT-3, Gibson Girl (Ref. 25). A life raft radio beacon weighing approximately 40 pounds with a self-contained, hand-operated generator. The unit requires a 300-foot long, balloon-raised antenna for operation. Range can be up to 1600 miles depending on atmospheric conditions, frequency, etc. A program has been initiated for the development of a lighter, smaller, battery-powered high-performance replacement for the AN/CRT-3.

Additional Aids

Chaffing System (Ref. 26). The B58-A aircraft ejection capsule is equipped with a chaffing system which dispenses shredded tinfoil strips into the atmosphere, aiding radar signal reflection and affording a means of capsule location. As the capsule is ejected, an aneroid unit senses the pressure change and automatically opens the compartment containing the chaff. The slipstream then dispenses the chaff during capsule descent.

Radar Reflectors (Ref. 27). The most commonly used is the corner, or "target," reflector which is an umbrella-like antenna made of 8 triangular planes of metal mesh that intersect at right angles. Effective range of the reflector is 2 to 18 miles.

MK-13 MOD O Distress Signal (Ref. 28). The distress signal is a pyrotechnic torch that burns for approximately 18 seconds. Signals are located on both ends of the cylindrical container, with orange smoke for day and red glow for night.

Pencil Flare M-131 (Ref. 29). These are small, pencil-sized flares which may be carried on the aviators person, and used principally for signal during parachute descent.

Dye Marker (Ref. 27). Dye marker packets are worn, attached to life vests, and carried in life rafts. Under good conditions the dye is exhausted in 20-30 minutes and ceases to be a good target after 1 hour. It is visible at an approximate distance of 10 miles at 3,000 feet.

Signal Mirror (Ref. 27). Hand mirror which can usually be seen at a distance three to five times greater than the distance at which a life raft can be sighted at sea. On a clear day, the mirror will reflect the equivalent of 8 million candlepower. Flashes from a mirror have been seen from a distance of 40 miles.

Whistle (Ref. 27). This signalling device can be heard up to a distance of 1,000 yards.

38 Caliber Revolver with Tracer Bullets (Ref. 28).

(4) Survival Equipment and Containers

The increased range of today's high-performance aircraft has changed the concept of survival kit configurations, packaging, and component items. The individual kit must now provide the downed aircrew member with a capability to supplement living off any environment; e.g., arctic, tundra, jungle, or desert regions, as well as the sea. There are several types of survival kits used by both Air Force and Navy. These kits are packed for either individual or aircrew use, in the container most adaptable to the aircraft and area over which the flight will take place; however, most kits presently are packed for global survival. The following are examples of survival equipment containers and survival equipment now in use. (This information was obtained from Refs. 19 and 30).

Survival Equipment Containers

MD-1 Container. Global kit container used primarily in ejection seats of various types of fighter and bomber aircraft. Consists of an outer expandable fabric container and a waterproof inner container. Container size may be adjusted with a drawstring positioned around the bottom edge of the container.

ML-2 Container. Global kit container used in B-52 and B-58 aircraft consists of a fiberglass or reinforced plastic container with an inner waterproof container.

Containers Applicable to F-101, F-102, F-104, F-105, and F-106 Aircraft. These are rigid survival kit containers which are similar in configuration to the ML-2 container, the basic difference being that these kits contain an integrated emergency oxygen system containing a 10 minute supply of oxygen for breathing and maintaining a pressure suit.

Container for Rotational Upward Ejection Seat. Container used in the F-106A and F-106B aircraft. Kit consists of two detachable fiberglass packs which attach to the back of the seat.

F-4H-1 Container. This container is part of the Martin-Baker ejection seat installation in the F-4 series, all-service aircraft. Container is a rigid, molded, two-part assembly which is carried in the seat pan and is attached to the integrated lap belt assembly.

ML-3 Container. A long-range, nonejection kit, normally stowed in a place readily accessible to the crewmember, may be attached to either back- or chest-style parachute accessory V-rings before bailout. The kit may be worn as a rucksack after landing.

Other Survival Items. The following lists itemize mandatory, recommended, and optional items for inclusion in survival equipment:

SURVIVAL EQUIPMENT

MANDATORY

Quantity	Item	Use	Weight	(Cu in)
1	Mirror MK3, BuAer Spec 23M5	Signal, Operational	6 oz	4
3	Signal, Smoke and Illumination, Marine Mk13, Mod 0 (SAC--Optional if Radio Is Used)	Hand-held, daytime, night-time flare	4 oz	10
2	Signal, M131, Illumination	Signal		
1	Whistle, Police, Plastic (SAC--Optional)	Signal	2 oz	2
1	Radio Set, AN/URC-11 or	Signal	1 lb	110
1	Radio Set, AN/URC-10	Signal	1 lb	110
1	Battery, Type BA1315/U	with Radio		
1	Battery, Type BA1387/URC-10	with Radio		
1	Cable Assy (Comes w/ Radio)	with Radio		
3	Box, Match, Waterproof 60B3693	For Stowing Matches	2 oz	6
1	Life Raft, MB-4	Flotation	7 lb 4 oz	
100 (Approx)	Matches, Strike-Anywhere Kitchen	Store in Waterproof Match Box		
1	Radiac Meter (SAC Only)	Radiation		
1	Manual, Survival	Instruction Manual	3 oz	

SURVIVAL EQUIPMENT (Cont)

MANDATORY

Quantity	Item	Use	Weight	(Cu in)
1	Water, Drinking, Canned (SAC)			

RECOMMENDED ITEMS

Quantity	Item	Use	Weight	(Cu in)
1 pr	Socks, Wool, Cushion Sole	All Climatic Ranges	2 oz	N/A
1 pr	Socks, 100% Down Insulated	All Climatic Ranges	8 oz	25
1 pr	Socks, Wool, Winter	All Climatic Ranges	3 oz	N/A
1 pr	Goggles, Sun, Type I or II	Against Sun and Snow Blindness	3 oz	5
1	Lipstick, Anti-Chap, Type I, II	Type 1, Arctic Use; Type 2, Tropic Use	1 oz	1
1	Repair Kit, Life Raft		4 oz	24
2	Ration, RS-1	Food Ration	1 lb 8 oz	85
3 tubes	Sodium Chloride Tablets	Heat Fatigue	1 lb 5 oz	1.5
1	Spoon, Spec MIL-F-284		1 oz	1
100	Cartridge, Ball, Cal. 22, Hornet	M-4 and M-6 Survival Weapons		
1	Packet Sea Marker	Signal		9
1	Shark Deterrent			9
1	Kit, Fishing, Survival	Foraging Equipment	5 oz	7
1	Net, Gill, Nylon	Fishing	2 oz	N/A
1	Oiler, Carbine, Cal. 30. M-1	Survival Weapons	3 oz	1

SURVIVAL EQUIPMENT (Cont)

RECOMMENDED ITEMS

Quantity	Item	Use	Weight	(Cu in)
1	Rifle, Survival, M-4, 22 Hornet	Foraging	3 lb 10 oz	90
20 ft	Wire, Comm. Brass	For Making Snares	2 oz	N/A
1	Candle, Long-Burning, MIL-C-25539	Emergency	N/A	N/A
1 box, 24 ea.	Heat Tabs, J. W. Speaker, P/N 1118	Heat, Cooking	N/A	N/A
1	First Aid Kit, Survival, Individual	First Aid	6 oz	12
1	Bag, Sleeping, MC-1, Dwg No 59D3988	All Climatic		350
1	Saw, Hand, Finger Grip, MIL-C-380, Type MB-2	Cutting Metals, Wood, Plastic, Glass in Any Direction		
1	Knife, Pocket, Spec MIL-J-818	Combination, Screwdriver, Opener, 4 Blades	4 oz	1.69
1	Stone, Sharpening, Type VIII		2 oz	2.65
1	Compass, Pocket, MIL-C-6235		1 oz	1
1	Compass Lensatic	Reading Azimuths	4 oz	8
1	Bag, Storage, Drinking Water, Size B, MIL-B-8571	Storing Drinking Water	3 oz	
1	Canteen, Plastic (3 Pints)		2 oz	
1	Bag, Storage, Drinking Water, Size A, MIL-B-8571	Storing Drinking Water	3 oz	

SURVIVAL EQUIPMENT (Cont)

RECOMMENDED ITEMS

Quantity	Item	Use	Weight	(Cu In)
1	Kit, Desalting, MK-2, MIL-D-5531	Drinking Water from Salt Water	1 lb 6 oz	36
1	Magazine, 22 Hornet	M4, Weapon	4 oz	6
1	Radiac Meter, Minirad	Detecting Gamma Radiation	8 oz	15
1	Hood, Winter MIL-H-25764			
1	Pocket Flare Kit	Signal		

OPTIONAL ITEMS

Quantity	Item	Use	Weight	(Cu In)
1 pr	Drawers, Wool, MIL-D-2224	Cold Climate	12 oz	49
1	Jacket, 100% Down Insulated	Cold Climate	2 lb	150
1 pr	Gloves, Inserts	Cold Weather When Finger Dexterity Required	2 oz	6
1	Trousers, 100% Down Insulated	Cold Climate	2 lb	125
1 pr	Mittens, Aircrew	Cold Temperate Climate	1 lb	14
1 pr	Mittens, Inserts	Liner for N-2	1 lb	20
1 pr	Gloves, Cloth, Work, MIL-G-2874, Type I	Hot Climate	5 oz	10
1	Hat, Reversible, Sun	Hot Climate	8 oz	16
1 pr	Moccasin, Survival, Type II	Cold Climate	1 lb	20
1	Poncho, Lightweight	Cold Climate	2 lb 8 oz	50
1	Undershirt, Winter	Cold Climate	8 oz	108

SURVIVAL EQUIPMENT (Cont)

OPTIONAL ITEMS

Quantity	Item	Use	Weight	(Cu in)
1	Insect Repellent	Insect Repellent	4 oz	6.7
1	Hat and Mosquito Net	Insect Protection	3 oz	
1	Ointment, Sun	Sunburn	3 oz	5.5
2	Food Packet, Type SA	Food for 1 Man, 1 Day, Cold Climate	1 lb 3 oz	49
1	Food Packet, Type ST	Food for 1 Man, 3 Days, Tropics	1 lb 3 oz	49
1	Rifle, Shotgun, M6, 22 Hornet, 410 Gage	In Place of M-4 Rifle	3 lb 10 oz	90
1 Box	Shell, 410 Gage, 3 in Case	For M-6 Weapon	1 lb.	
2	Starter, Fire, Type M2, Spec MIL-S-13175	Starting Fires		
1	Snake Bite Kit, Suction	Snake Bites	5 oz	13
1	Razor, Safety, Travel Kit 57C3785			
1	Soap, Toilet, Floating	Personal	2 oz	1
1	File, Flat, 6 in., Type 3		3 oz	.6
1	Knife, Hunting, w/Sheath		5 oz	27
1	Survival Tool Kit Type SRU-18/P Dwg. 62D4406	Comb. Tool		
1	Plotter, Type B-2	Measuring Angles, Distance	8 oz	12
1	Hand Axe, 16 in Handle		1 lb 4 oz	40

(5) Automatic Life Raft (Walter-Kidde Co. Ltd.)

In the past, many injuries have been sustained by flying personnel, either due to combat or through ejection from high-speed aircraft, making it difficult or impossible to carry out the manual operations necessary to inflate the conventional type of emergency life raft. An automatic, single-seat life raft is now available which eliminates the previous necessity of manual operation. The only conscious activity required in the automatic system is that the pilot successfully ejects himself from the aircraft (Ref. 31).

The dinghy is basically the standard, boat-shaped, pneumatic, one-man raft, but has a small diameter, high-pressure tube attached to the periphery of the main buoyancy tube which spreads the raft beneath the subject, ready for inflation, after a predetermined interval.

On separation from the ejection seat, the pilot's life jacket is inflated and the raft deployment tube operating head is primed, both actions being performed by a static line. Upon entering the water the pilot gains immediate support from his life jacket. Following a period of 10 to 15 seconds the deployment tube inflates, spreading the dinghy under him. At this stage, the operating head of the main tube is primed. After a further interval of 10 to 15 seconds, the main buoyancy tube inflates and the subject is fully supported by the dinghy. Automatic inflation of the raft is accomplished through soluble plugs which are shielded from the water until the inflation mechanisms are primed in proper sequence. See Fig. 230 for an inflation sequence following water touchdown.

In the case of aircraft ditching and abandonment, the only departure from the fully automatic mode is manual operation of the inflation mechanism of the life jacket. Underwater escape is feasible with this system. While submerged, the pilot ejects from the aircraft in the normal manner. Separation of the pilot from the seat is assisted by inflatable bags which are situated in the seat; these bags automatically inflate during the initial stages of ejection. The life jacket and life raft then automatically inflate in their normal sequence.

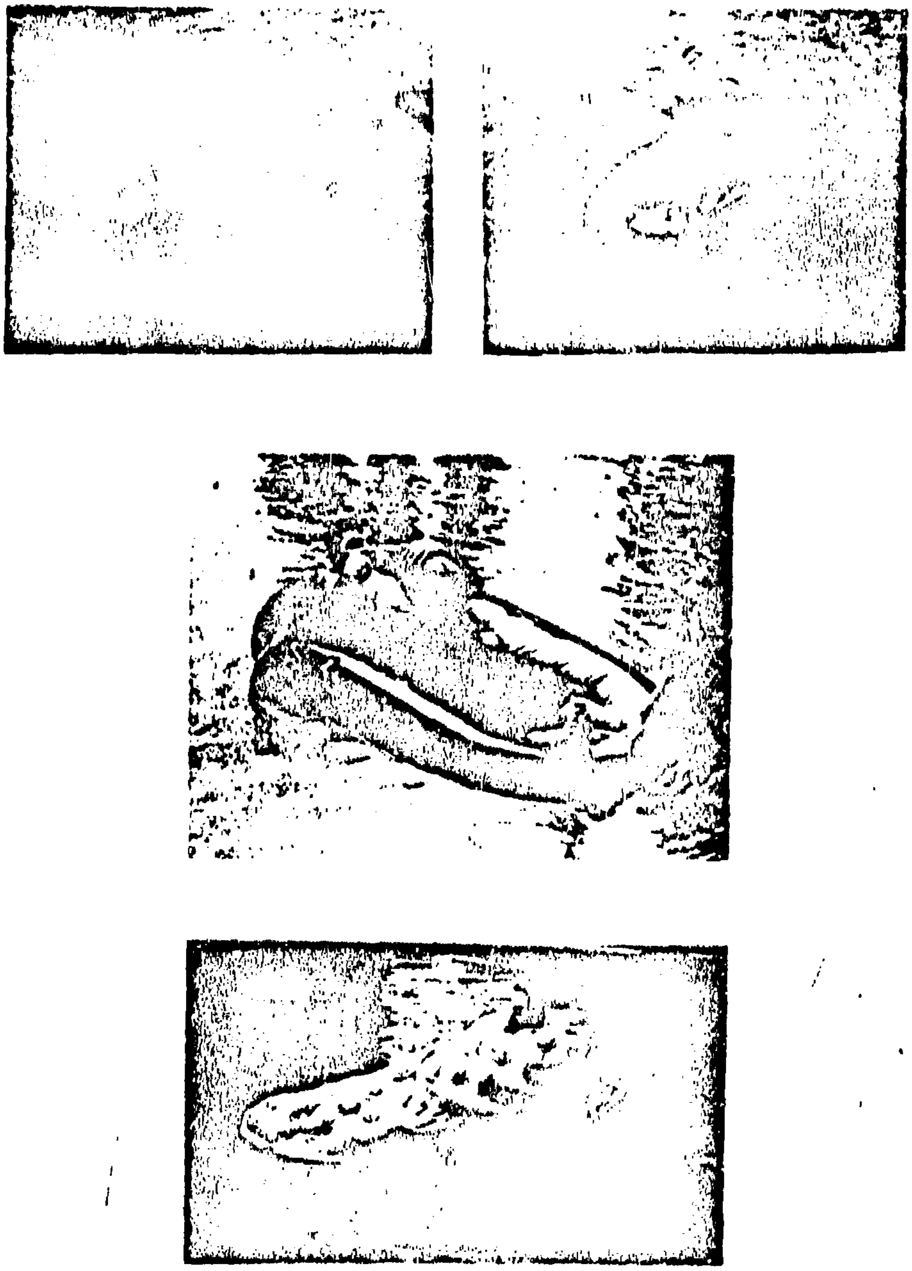


Figure 230. Walter-Kidde Automatic Life Raft, Inflation Sequence Following Water Touchdown

SECTION III

ESCAPE SYSTEM EVALUATION

Comparisons were made of the design factors involving escape capability, subsystems, weight, and development/production status for like escape system concepts investigated during this phase of the program. A comparison of these factors is shown in Table XXXIV for ejection seats, Table XXXV for encapsulated ejection seats, and Table XXXVI for escape capsules.

	CONVAIR "B"	DOUGLAS ESCAPAC I-C	DOUGLAS ESCAPAC II	LOCKHEED C-2	MARTIN-BAKER	NORTH AMERICAN X-15	NORTH AMERICAN HS-1	NORTH AMERICAN LS-1	NORTH AMERI LW-1
ESCAPE CAPABILITY	S.L. TO 50,000 FT 150 TO 790 KEAS	S.L. TO 50,000 FT 0 TO 600 KEAS	S.L. TO 50,000 FT 0 KNOTS TO MACH 1	S.L. TO 50,000 FT 100 TO 550 KEAS CAN EJECT THRU CANOPY	S.L. TO 50,000 FT 100 TO 600 KEAS NORMALLY EJECTS THRU CANOPY	S.L. TO 60,000 FT 90 TO 700 KEAS 60,000-120,000 FT UP TO MACH 4.0	S.L. - 70 TO 750 KEAS 15,000 - 70,000 FT UP TO MACH 2.2	S.L. TO 40,000 FT 50 TO 525 KEAS MACH LIMIT 1.0 CAN EJECT THRU CANOPY	S.L. TO 10,00 0 TO 30 KEAS CAN EJECT TH CANOPY
CREWMAN RESTRAINT	INTEGRATED HARNESS INERTIA REEL, FOOT PANS AND FOOT RETRACTION REELS, LEG GUARDS	INTEGRATED HARNESS INERTIA REEL	INTEGRATED HARNESS, BALLISTIC INERTIA REEL	FOOT RETRACTION, LEG GUARDS, ARM SUPPORT WEBBING LAP BELT AND SHOULDER HARNESS	TORSO HARNESS FOOT AND LEG RESTRAINT CORDS	INTEGRATED HARNESS, ARM RESTRAINT, LEG BRACES, FOOT RETENTION	TORSO HARNESS ARM AND LEG RESTRAINT	INTEGRATED HARNESS (TORSO SUIT), BALLISTIC INERTIA REEL	INTEGRATED HARNESS, IN INERTIA REEL
CATAPULT AND/OR ROCKET MOTOR	ONE VERTICAL & TWO ROTATIONAL DAMPED THRUSTERS TWIN ROCKET MTRS R.P.I. P/N 1378	ROCKET CATAPULT R.P.I. P/N 2174-16	ROCKET CATAPULT	ROCKET CATAPULT FRANKFORD ARSENAL P/N XM10	MARTIN-BAKER EJECTION GUN ONE PRIMARY AND TWO SECONDARY CHARGES	ROCKET CATAPULT (CANOPY FIRED) TALLEY P/N 10100-9	ROCKET CATAPULT R.P.I. P/N 1200-4A	ROCKET CATAPULT R.P.I. P/N 1192	ROCKET CATA FRANKFORD ARSENAL MODIFIED XM WITH XMIU N
STABILIZATION DEVICES	TWO TELESCOPING BOOMS	DART SYSTEM	DART SYSTEM 42 INCH CHUTE		22 IN. CONTROLLER AND 5 FT. CHUTE	FINS AND BOOMS	52 INCH CHUTE	DROGUE CHUTE	
SEAT-MAN SEPARATOR	PERSONNEL OR DRAG CHUTE	TWO INFLATABLE BLADDERS	PERSONNEL CHUTE DEPLOYMENT	BALLISTIC ROTARY ACTUATOR	PERSONNEL PARACHUTE	PERSONNEL PARACHUTE	TWO INFLATABLE BLADDERS	TWO INFLATABLE BLADDERS	PERSONNEL PARACHUTE
PERSONNEL PARACHUTE	ANEROID CONTROL EJECTOR GUN DEPLOYS PILOT CHUTE	ANEROID-BALLISTIC CONTROL PACK OPENING NB-9 28 FT. CANOPY	ANEROID CONTROL BALLISTIC GUN DEPLOYED NB-9 28 FT. CANOPY	ANEROID CONTROL PACK OPENING BA-15 PARACHUTE	TIME, "G" AND ANEROID CONTROL 24 FT. CANOPY	ANEROID CONTROL 24 FT. FLAT CIRCULAR CANOPY	ANEROID - TIME CONTROL NB-7E 28 FT. CANOPY	ANEROID - TIME CONTROL NB-7 28 FT. CANOPY	ANEROID-BA GUN, PA-7, PILOT CHUTE CANOPY
SYSTEM INITIATION	SEAT D RING	FACE CURTAIN AND SEAT D RING	FACE CURTAIN AND SEAT D RING	SEAT D RING DUAL BALLISTIC SYSTEM	FACE CURTAIN AND SEAT D RING	HAND GRIPS ON BOTH SIDES OF SEAT	FACE CURTAIN AND HAND GRIPS ON BOTH SIDES OF SEAT	FACE CURTAIN AND SEAT D RING	SEAT D RING DUAL BALLI SYSTEM
SURVIVAL EQUIPMENT	TWO SEAT BACK SURVIVAL PACKS	PK-2 PARARAFT KIT	PK-2 PARARAFT KIT	SURVIVAL KIT	PK-2 PARARAFT KIT	EMERGENCY OXYGEN SUPPLY	SURVIVAL KIT	SURVIVAL KIT	SURVIVAL K
WEIGHT POUNDS (MAN NOT INCLUDED)	417	149	156	266	235	260 (APPROX.)	353	170	104
DEVELOPMENT/ PRODUCTION STATUS	F-106	LING TEMCO-VOUGHT XC-142 AND A-7A CANADAIR CL-84 DOUGLAS TA-4F LOCKHEED XV-4A G.D. - "COIN"	TEST AND DEVELOPMENT	F-104	TF9J, AF9J, F-11A, AO-1, A-6A, AF-1E, F-6A, F-3C, F-4B, F-8A, RF-8A, F-8B, T-1A	X-15	A-5 (A3J)	T-2A (T2J-1)	US ARMY TEST VEHIC

A

I AMERICAN	NORTH AMERICAN LW-1	NORTH AMERICAN LW-2	NORTH AMERICAN LW 3B	WEBER F 106	WEBER T-37	WEBER GEMINI	WEBER DYNASOAR	WEBER LLRV	BOEING B-52 UPWARD
O 41,000 FT 325 KIAS LIMIT 3.0 JECT THRU PY	S L TO 10,000 FT 0 TO 300 KEAS CAN EJECT THRU CANOPY	S L TO 50,000 FT 0 TO 500 KEAS MACH LIMIT 2.0 NORMALLY EJECTS THRU CANOPY	S L TO 25,000 FT 0 TO 500 KEAS CAN EJECT THRU CANOPY	S L TO 50,000 FT 0 TO 600 KEAS	S L TO 40,000 FT 120 TO 400 KEAS	S L TO 70,000 FT 0 TO 600 KEAS	S L TO 50,000 FT 0 TO 515 KEAS UP TO MACH 0.8 AT 50,000 FT	S L TO 40,000 FT 0 TO 300 KEAS	S L TO 50,000 FT 120 TO 453 KEAS
IATED SS TORSO BALLISTIC A REEL	INTEGRATED HARNESS, INO INERTIA REEL	INTEGRATED HARNESS, POWER INERTIA REEL	INTEGRATED HARNESS, POWER INERTIA REEL	INTEGRATED HARNESS, POWER INERTIA REEL ON AFT SEAT ONLY	LAP BELT AND SHOULDER STRAPS, INERTIA REEL, LEG GUARDS	INTEGRATED HARNESS, INERTIA REEL	LEG AND ARM SUPPORT, POWER INERTIA REEL, BODY RESTRAINT	INTEGRATED HARNESS, INO INERTIA REEL	INTEGRATED HARNESS INERTIA REEL
T CATAPULT P/N 1192	ROCKET CATAPULT FRANKFORD ARSENAL MODIFIED XM9 WITH XM10 NOZZLE	ROCKET CATAPULT	ROCKET CATAPULT U.S. NAVY P/N EX 12 MOD 0	ROCKET CATAPULT R P I P/N 2174 518	CATAPULT FRANKFORD ARSENAL P/N M5	ROCKET CATAPULT R P I P/N 2194-15	ROCKET CATAPULT FRANKFORD ARSENAL P/N XM10-E1	ROCKET CATAPULT R P I P/N 2124-15	CATAPULT FRANKFORD ARSENAL P/N M3
N CHUTE		52 INCH CHUTE				4 FT GOODYEAR BALLUTE			
NFLATABLE IERS	PERSONNEL PARACHUTE	PERSONNEL PARACHUTE	PERSONNEL PARACHUTE	BALLISTIC ROTARY ACTUATOR		WAC THRUSTER AND STRAPS	BALLISTIC ROTARY ACTUATOR	BALLISTIC ROTARY ACTUATOR	
OID - TIME ROL NB-7 CANOPY	ANEROID BALLISTIC GUN, PA-7, 36 INCH PILOT CHUTE, 28 FT CANOPY	BALLISTIC GUN OR STABILIZATION CHUTE DEPLOYS 28 FT CANOPY	BALLISTIC GUN NB-7 28 FT CANOPY, SPRING DEPLOYED PILOT	ANEROID CONTROL WAC DROGUE GUN B-18 PARACHUTE	ANEROID - F-18 TIMER CONTROL BA-15 CHUTE C-9 CANOPY	BALLISTIC MORTAR 40 IN. PILOT CHUTE C-9 CANOPY	ANEROID - TIME CONTROL B-5 PACK C-9 CANOPY	WAC DROGUE GUN B-4 PACK WITH C-9 CANOPY	ANEROID - TIME CONTROL B-5 PACK C-9 CANOPY
CURTAIN AND D RING	SEAT D RING DUAL BALLISTIC SYSTEM	SEAT D RING DUAL BALLISTIC SYSTEM	SEAT D RING	HAND GRIPS ON BOTH SIDES OF SEAT	TRIGGER IN RIGHT LEG GUARD	SEAT D RING BOTH SEATS FIRED BY EITHER PILOT	TWO-HANDED CONTROL	SEAT D RING	TRIGGER ON RIGHT ARMRESTS
IVAL KIT	SURVIVAL KIT	SURVIVAL KIT	SURVIVAL KIT	SURVIVAL KIT		SURVIVAL KIT	SURVIVAL KIT		SURVIVAL KIT
170	104	179	153	212	130	220	216	170	216
A (Q3)-II	US ARMY TEST VEHICLES	G E - RYAN XV-5A LOCKHEED XV-4A CURTISS-WRIGHT X-19 NAA YAT-28E	NAVY OV-10A	F-106	CESSNA T-37	GEMINI CAPSULE	DESIGN AND DEVELOPMENT	GROUND FIRING TESTING ACCOMPLISHED	B-52

B

	ESCAPE CAPABILITY	CREWMAN RESTRAINT	CATAPULT	STABILIZATION DEVICES
GOODYEAR ENCAPSULATED SEAT	SL to 55,000 ft at max speed of 800 knots; 55,000 ft to 100,000 ft at Mach 4.0; 150 knots under landing or take-off conditions	Torso positioning and restraint; foot retraction; arm guarding	Solid propellant rocket engine, Frankford Arsenal P/N XM-7	Stabilization drag body
NORTH AMERICAN B-70 ENCAPSULATED SEAT	SL to altitudes exceeding 100,000 ft from 90 KEAS to supersonic speeds up to Mach 3.1	Torso positioning and restraint; foot positioning; forearm supporting	Rocket catapult, Rocket Power Inc. P/N 1720-10	Stabilization booms with boom tip deployed parachutes
STANLEY B-58 ENCAPSULATED SEAT	SL up to 600 knots and to Mach 2.2 up to 80,000 ft; ground level between 100 and 285 knots	Torso positioning and restraint by inertia reel, Pac.-Sci. P/N 010 3114-2; leg retraction and positioning	Rocket catapult, Thiokol P/N A273-1006-1	Stabilization frame and stabilization parachute
STANLEY TWO-PLACE ENCAPSULATED SEAT	0 to 300 KEAS at ground level and up to Mach 1.25 at near GL up to Mach 3.0 between 42,000 ft and 80,000 ft	Torso positioning and restraint; leg and foot retraction and restraint; arm and knee guarding	A separate catapult and rocket	Stabilization booms

			DESIGN FACTORS		
CREWMAN RESTRAINT	CATAPULT	STABILIZATION DEVICES	RECOVERY DEVICES	GROUND IMPACT ATTENUATION	S' INI
Torso positioning and restraint; foot retraction; arm guarding	Solid propellant rocket engine, Frankford Arsenal P/N XM-7	Stabilization drag body	One 35-foot diameter extended skirt parachute	Buffer bag	Two c trigge secon tie fir pre-ej systen manua of sec ballist recov
Torso positioning and restraint; foot positioning; forearm supporting	Rocket catapult, Rocket Power Inc. P/N 1720-10	Stabilization booms with boom-tip deployed parachutes	One 34.5-foot diameter solid extended skirt canopy	Inflatable bladder plus stabilization booms	Two ej trigge manua of rec chute
Torso positioning and restraint by inertia reel, Pac.-Sci. P/N 010 3114-2; leg retraction and positioning	Rocket catapult, Thiokol P/N A273-1006-1	Stabilization frame and stabilization parachute	One 41-foot diameter ring-sail parachute	Two yielding metal cylinders plus cutting of flanges by the stabilization frame fins	Two e trigge dual c firing; manua jettiso manua parach ride h
Torso positioning and restraint; leg and foot retraction and restraint; arm and knee guarding	A separate catapult and rocket	Stabilization booms	Two 41-foot diameter ring-sail parachutes	Stabilization booms in bending and in shearing of metal in landing gear support struts	Manua jettiso manua parach ment

Table XXXV. Encapsulated Ejection Seats Comparison

'ORS				
GROUND IMPACT TTENUATION	SYSTEM INITIATION	SURVIVAL EQUIPMENT	INSTALLED WEIGHT	DEVELOPMENT/ PRODUCTION STATUS
Buffer bag	Two ejection triggers; secondary ballistic firing of pre-ejection system; manual initiation of secondary ballistic firing of recovery system	Space provided for 110 cu in of survival gear	689.4 pounds including 200-pound man	Preliminary design and dynamic model and wind tunnel model tests
Inflatable bladder plus stabilization booms	Two ejection triggers; manual initiation of recovery parachute deployment	Survival equipment stowed in two containers beside crewman's head and in an underseat compartment; emergency radio beacon; chaff dispenser	864 pounds including 200-pound man	Development and qualification test program accomplished; produced for XB70 airplanes.
wo yielding etal cylinders us cutting of anges by the abilization ame fins	Two ejection triggers; dual catapult firing; manual canopy jettisoning; manual recovery parachute override handle	56-3/4 pounds of survival equipment with capsule; chaff dispenser; radio transceiver	706.2 pounds including 200 pound man	Developed, qualified, and produced for the B-58 airplanes
tabilization ooms in ending and shearing of etal in nding gear upport struts	Manual canopy jettisoning; manual recovery parachute deployment	Automatic "May-day" signal over airplane radio; chaff dispenser. Suitable survival gear for test aircraft	1408 pounds including two 177-pound 50th percentile men	Wind tunnel tests conducted; design is a further development of B-58 encapsulated seat

	CHANCE - VOUGHT CAPSULE	LOCKHEED F-104 CAPSULE	VERTOL H-25 CAPSULE
ESCAPE CAPABILITY	Zero alt landing stall speed to Mach 1.4 and to Mach 4.0 at 55,000 ft	Sled tests from static to 700 KEAS	Feasibility study for hover or cruising speed above 100 ft alt
CREW RESTRAINT	Not specified	Not specified	Not specified
BOOST ROCKETS	2 solid motors, total thrust 30,000 lb total impulse 26,000 lb per sec, electrically started	Solid motor, thrust 45,000 lb burn time 0.5 sec squib started	None
SEPARATION	Linear-shaped charges	Gas-operated piston assemblies which free attachment fittings	Shaped charges for rotors, shafts, and fuselage; ballistic guillotines for lines, cables, and wires
STABILIZATION	Four external stabilizing fins are actuated at separation	Three wedge-shaped booms 7-1/2 ft long, triangular cross-section	Not specified
GROUND IMPACT ATTENUATION	Four 35.7-in. dia inflatable bags	Not specified	Not specified
FLOTATION	Two 30-in. flotation bags	Not specified	Not specified
RECOVERY PARACHUTES	9-ft dia ribbon decel parachute (1st stage) Cluster of three 40.5-ft dia flat circular parachutes (2nd stage)	Main parachute 71.5-ft dia ring, slot parachute	Four ultra-fast-opening 35-ft parachutes
NO. OF CREWMEMBERS	1	1	2
SURVIVAL EQUIPMENT	Rescue detection and emergency communications	Not specified	Not specified
WEIGHT	3,500 lb	2,400 lb	2,700 lb (includes 2 passengers)
DEVELOPMENT	Developed for F8U-1 capsule	Track test on F-104 capsule	Ground feasibility test conducted

RTOL H-25 APSULE	BOEING SUPERSONIC CAPSULE	BOEING ADO-12 CAPSULE	CONVAIR F-111 COCKPIT POD CAPSULE
ility study for or cruising above 100 ft	Zero-zero to Mach 1.2 at sea level and to Mach 2.5 30,000 to 60,000 ft	Zero-zero to Mach 1.2 at sea level and Mach 3.0 at 70,000 ft	Zero-zero to max vehicle capability
ecified	Restraint harness	Not specified	Basic harness with lateral chest straps - powered inertia reel
None	Solid motor, thrust 65,310 lb for 0.6 sec	Solid motor, thrust 68,000 lb for 0.6 sec	Two-mode binozzle, approx 26,000 lb for 0.8-sec basic single nozzle thrust
charges for shafts, and e; ballistic nes for lines, and wires	Rocket exhaust gas pressure initiates linear-shaped charges.	Linear-shaped charges	Shielded mild detonating cord, flexible linear shaped charge, ballistic guillotines, and disconnects
ecified	Two 4-ft dia first ribbon stabilizing parachutes	One 6-ft dia conical stab parachute deployed from each of 4 telescoping drogue booms	Wing glove, pitch flaps, and one 6-foot diameter hemisflo parachute
ecified	Crushing of structure forward of pilots compartment	Not specified	Impact bags
ecified	Two stab & 1 righting cell +2 fwd and 1 rear flotation cell total vol = 76.4 ft3	Flotation sys similar to Boeing supersonic	Flotation bags
ltra-fast- ; 35-ft para-	Two 63-ft dia modified ring sail parachutes plus 12-ft fist ribbon decel parachute	74.2-ft dia ringsail parachute	One 70-foot diameter ringsail parachute
2	2	2	2
cified	Emergency transceiver and flashing beacon light	Survival equipment, 2 location aids within capsule	Survival equipment and location aids within capsule
(includes ngers)	5,000 lb	4,000 lb	3,000 lb
feasibility ducted	Prelim design, model wind tunnel & model flotation sys tests	Preliminary design	Operational

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13. ABSTRACT

A comprehensive group of appropriate open ejection seats, encapsulated ejection seats, cockpit pod capsules, separable nose capsules, and subsystems are described. The descriptions provide information on items such as initiation, crew positioning and restraint, emergency pressurization and oxygen, seat-man separation, capsule separation, rocket motors, rocket catapults, stabilization, deceleration, recovery parachute, landing impact attenuation, flotation, location aids, and survival equipment or provisions. Information is also provided on escape system performance, tests, accelerations experienced, stability characteristics, trajectories, escape time sequence, envelope dimensions, weights, production or development status, and projected system improvements.

14 KEY WORDS	LINK A		LINK B		LINK C	
	ROLE	WT	ROLE	WT	ROLE	WT
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Open Ejection Seats						
Encapsulated Seats						
Nose Escape Capsules						
Pod Escape Capsules						

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